U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1726

TREATMENT AND CARE OF TREE WOUNDS

QUESTIONS CONCERNING the proper treatment of wounds in shade, ornamental, roadside, street, and park trees (often long-neglected wounds) are being constantly received by the Department of Agriculture. This bulletin was designed to answer such of these questions as have been most frequently asked. It is intended primarily for persons in charge of private or public property with little or no knowledge concerning the normal life processes of a healthy tree nor of why and how wounds endanger the health of trees.

Well-established tree-surgery firms, located in various parts of the country, are prepared to handle all grades of tree work ranging from the simplest to the most complicated. Many of these have their own special methods, which in expert hands are usually quite satisfactory. There are many persons, however, who prefer, either from choice or necessity, to attend to the wounds in their own trees, and the information in this bulletin is intended to serve as a guide for such persons. Most of the simpler types of work are entirely within the range of almost any practical man who is familiar with the use of a saw, gouge, mallet, and paintbrush.

Two axioms that should be borne in mind constantly are (1) that prompt treatment of freshly made wounds is the surest and best method of preventing disease or decay and needless expense in the future, and (2) that all old wounds should be treated as soon as possible by some method similar to those described in this bulletin.

The following bulletins give information on the selection, planting, and care of trees for shade and ornamental purposes: Farmers' Bulletin 1087, Beautifying the Farmstead; Farmers' Bulletin 1208, Trees for Town and City Streets; Farmers' Bulletin 1209, Planting and Care of Street Trees; Farmers' Bulletin 1481, Planting the Roadside; Farmers' Bulletin 1482, Trees for Roadside Planting; Farmers' Bulletin 1591, Transplanting Trees and Shrubs; and Farmers' Bulletin 181, Pruning. They may be purchased from the Superintendent of Documents, Washington, D.C., for 5 cents a copy.

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TREATMENT AND CARE OF TREE WOUNDS

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CONTENTS

NEGLECTED WOUNDS

WOUNDS OF ALL SORTS are so common on trees that most people have become oblivious of the damage arising from neglected wounds, or at least they underrate the possibilities of damage. Every broken limb and every other kind of external wound that penetrates to the inner bark may allow active plant or animal parasites or rot-producing organisms to enter unless these injuries receive prompt and proper treatment and care.

The best, safest, and most economical means of preventing future extensive decay, disfigurement, or premature death of a tree is to attend to each wound as soon as it occurs. This kind of work is simple and comparatively inexpensive. If a wound is allowed to remain untreated for some years (as commonly happens) decay-producing organisms almost invariably enter and produce a rotted area in the wood beneath, often so extensive that a violent wind may break the tree at the decayed and weakened spot. Roadside trees weakened by decay are especially dangerous to traffic. Uninjured bark or prompt and proper treatment of an injured area usually prevents the entrance of organisms causing decay.

If an untreated wound of several years' standing has developed a considerable area of decayed wood or bark, the first question to be considered is whether the tree or limb involved is of sufficient value to warrant the expense of properly treating it. Should it be decided to undertake the work, the too common mistake of neglecting portions

that are difficult to reach should not be made. Under ordinary conditions it should be a thorough, complete, and sanitary job, or else nothing whatever should be attempted. If a tree is badly decayed or injured, it may be better to remove it and set a healthy one in its place; or it may be braced or guyed to prevent breakage in a violent storm; or the decayed matter may be removed and the cavity treated in accordance with directions given in this bulletin. When large areas of rotted wood have been excavated and the cavities either filled or left open, the wounds will rarely heal completely. Careful and thorough cavity work on the trunk of a tree is of much greater importance than on a limb, primarily because the limb often may be cut off later well behind the diseased area, if need be, without materially impairing the general health of the tree.

Many people still fail to realize the full extent to which properly located, healthy, and well-kept trees enhance the value of real estate, particularly for residential purposes. From this point of view alone, it is wise to keep trees in a healthy and vigorous condition. Oftentimes historical association, scientific value, economic importance, or rarity of the species outweighs all other considerations. For various reasons trees are unquestionably a real asset whether on private, semiprivate, or public property, including highways and streets.

It costs comparatively little to treat recent wounds properly. Such treatment contributes greatly to the health, beauty, usefulness, and value of the trees in years to come. This is one of the great economic lessons connected with the care and treatment of trees.

Occasionally in this country, but more frequently in Europe, an old or irregular cavity is regarded as more ornamental and picturesque if left untreated. Undoubtedly the inrolling callus in such cavities contributes very materially to the strength of the trunk, in much the same manner that H- and I-beams strengthen a building or a bridge. It is usually advisable to reduce the size of the crown when a trunk is much weakened by decay, whether or not the decayed matter is removed and the cavity filled. This is done by cutting off a considerable portion of all the main limbs, which produces a more compact crown and lessens the strain on the weakened trunk.

STRUCTURE AND LIFE PROCESSES OF TREES

In order to undertake intelligently any cutting of tissues on an injured tree it is essential that one should know something about the normal life processes of a healthy tree and how mechanical injuries, decay, and cutting affect these processes.

A tree is composed of three main parts—the root, the stem, and the leaf. The root and stem are composed of the bark, the cambium, and the wood.

ROOT

The general structure of any large root is essentially the same as that of the stem, which is described below. The root and its many branches serve not only for anchorage, but also as passages for the entrance of water into a tree. Practically no water enters elsewhere. It enters chiefly through the root hairs and very small root branches, passes into the larger root branches, then up the trunk and out through the larger and smaller branches to the leaves.

STEM

A cross section of the stem or trunk, a large branch, or a root of almost any of our common trees shows that the bulk of it is composed of a central cylinder of wood surrounded by a comparatively thin mantle of bark (fig. 1).

BARK

The bark is composed of two parts; the dry outer corky bark (fig. 1, *a*), and the moist inner or living bark (fig. 1, *b*), both of which are made up of cells and tubes running lengthwise in the branches, trunk, and roots. The outer bark is dead bark tissue serving mainly as a protecting layer for the underlying living bark. It is doubtful whether organisms that cause decay can ever pass through an unbroken corky outer bark. It is through the inner bark that most of the transfer of organic food from the leaves to various parts of the tree takes place. Any injury to the living inner bark will react unfavorably on the general health of the tree. Such unfavorable reaction may be slight and imperceptible, or very pronounced, depending upon the severity of the injury and the ability of the particular tree to overcome that particular type of injury.

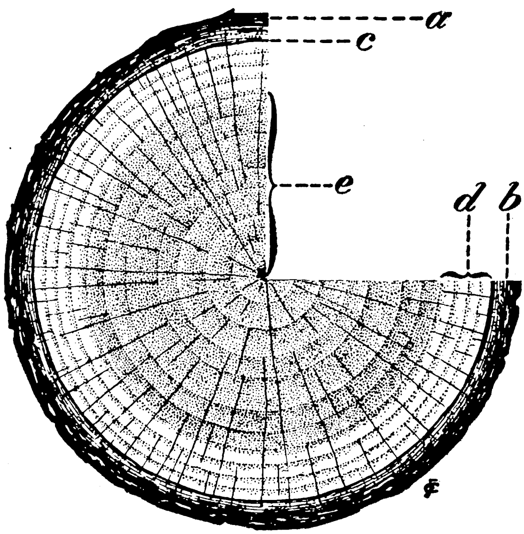

FIGURE 1.—Cross section of a typical tree trunk, showing the various parts: *a*, Outer corky bark; *b*, inner living bark; *c*, cambium; *d*, sapwood; *e*, heartwood. The concentric rings in the sapwood and heartwood are the annual rings. The radial lines extending part way or entirely from the center to the bark are the pith rays. In this figure the outer and inner bark are represented as approximately equal in thickness.

WOOD

The woody cylinder of the older trees, as seen in cross section, is commonly divided into two more or less well-defined regions, an outer lighter colored cylinder known as the sapwood (fig. 1, *d*) and an inner darker colored cylinder known as the heartwood (fig. 1, *e*). Sapwood and heartwood are not always distinguishable by color, however, and at times heartwood may be absent. Upon closer examination of the end of a section of most of the common trees of the Temperate Zone, it is generally possible to distinguish numerous concentric rings (often more or less irregular) throughout the sapwood and heartwood. These are known as annual rings (fig. 1), because under normal conditions a new one is formed each year.

The heartwood may be regarded as dead or nonconducting tissue which is useful mainly in giving rigidity or stiffness to the tree. This explains why the heartwood often can rot away, or be entirely removed, without causing serious injury other than impairing the strength of the tree. Most of the transfer of water from the soil to the leaves takes place through the sapwood.

CAMBIUM

Between the inner bark and the sapwood in all healthy parts of a tree there is a very thin continuous layer of young (embryonic) tissue, which is not necessarily sharply marked off from either bark or wood. This is the cambium (fig. 1, *c*). It is this layer that splits or slips so easily in the springtime when the bark is removed to make the familiar willow whistles of boyhood days. During the growing season its microscopic elements (cells) are constantly dividing and giving rise to new layers of cells on both sides, on the outer side of the cambium to new layers of bark, on the inner to new layers of wood. Thus, the youngest layers of both bark and wood are those adjoining the cambium. As the cambium is a very tender and thin-walled tissue, a comparatively slight injury will kill portions of it; and, once killed, the dead area can never again grow new bark or new wood. However, the healthy living cambium around the edges of the dead area will give rise each year to a new layer of more or less abnormal bark and wood. Under normal conditions these new layers of bark and wood (called callus bark and wood) will grow out each year over the margin of the dead area a little more than the width of an annual ring, and eventually the dead area, if not too large, may be entirely overgrown and hidden from view. Such dead spots furnish favorable places for the entrance of insects and organisms causing decay unless they are promptly and properly treated.

All new layers of the normal bark and wood of roots, trunk, and branches originate in the living cambium, never elsewhere. Consequently it is of the utmost importance to keep the cambium in a healthy and uninjured condition at all times. Diseases or injuries that kill large portions of the cambium usually kill the tree.

LEAF

Green leaves of the ordinary type are familiar to everyone. They are composed of veins made up of conducting tubes or tissues continuous with similar tissues in the wood and bark, while between the veins are several or many layers of variously shaped microscopic cells, which are specially adapted to perform the physiological functions that are essential to every living plant. Leaves are the structures or laboratories in which the organic food of the plant is manufactured from the inorganic food elements. Also they are the organs through which most of the water taken up by the roots is evaporated; furthermore, it is the leaves that are most active in absorbing oxygen and giving off carbon dioxide in the process of respiration, a process that is as necessary for all plants as it is for animals, and for analogous reasons.

WATER REQUIREMENTS

The water that enters a tree through the roots is not pure, but is a weak solution of many of the chemical substances found in the soil. When it reaches the leaves a very large proportion of it is given off in the form of a vapor of pure water. The chemical substances in solution are not evaporated. This means that practically all the chemical substances remain in the tree. As these enter the root in a very weak solution a relatively large amount of water must pass through the plant and be evaporated, in order to accumulate the

chemical substances that are to be utilized later in various ways as needed, or segregated and stored as useless or injurious substances.

Authentic records of many observers show that trees need a large amount of water to keep them in a healthy condition. A single oak tree is known to have given off into the air in the form of vapor more than 100 tons of water in a single growing season, and an acre of small beech trees more than 1,000 tons in a single season. Similar records show that an apple tree 30 years old gave off approximately a barrel of water each day, and a good-sized birch tree two barrels of water on a hot summer day. Other estimates show that the evaporation of 200 to 500 pounds of water is required for every pound of wood (dry weight) that is produced; also that a square yard of leaf surface commonly evaporates from half a pound to a pound of water each hour on a hot day. These figures give an idea of the amount of water that may be evaporated by certain trees, and of the importance of water to a tree.

Throughout the growing season this water flows continuously from the roots through the sapwood to the leaves. Unless the amount of water lost by evaporation (transpiration) is promptly, fully, and continuously replaced by water taken in by the roots, the foliage may wilt. Should this wilted condition continue for any great length of time the tree, or portions of it, may be permanently injured. If the wilting is slight or of short duration the injury may be temporary and subsequent recovery prompt, but if considerable or long continued it may cause serious injury or death. Severe injury also may result from a partial lack of water, particularly if long continued, where no obvious wilting of the foliage results. Examples of this type of injury may be seen after long-continued drought, or in the case of trees that normally require considerable water when they have been planted in dry situations or in sandy soil considerably above the water table. Roadside trees often suffer particularly from lack of water on account of the abnormal conditions under which they grow, the normal water table often being lowered by the highway surfacing and the construction of sidewalks, curbs, and gutters.

Wilting or injury may result not only from an actual lack of water in the soil but also from certain abnormal conditions when there is water in abundance in the soil, such, for example, as a sudden application of salt water (perhaps from an ice-cream freezer) or certain other chemical substances around the roots; or it may result from mechanical injury to the sapwood, or the removal of considerable portions of it, or from the cutting of roots, or from the clogging or drying out of the water-conducting tubes either in the stem or root as a result of disease, or from other abnormal conditions that interfere with the free transfer of soil water. Calcium chloride applied in excess as a dust palliative or temporarily stored along roads may injure trees.

If any great width of sapwood, as measured around the trunk, is removed or becomes useless through disease or injury, the tree may be seriously injured or killed, at least above the wound. Since the water from the soil moves upward primarily through the microscopic tubes in the sapwood, which run lengthwise in roots, trunk, and limbs, it is possible to remove a long and narrow strip of sapwood extending parallel with these tubes with less injury to the tree than would result from cutting out a shorter but broader area to an equal depth. This

is due to the fact that the broader cut severs and renders useless a greater number of these active water-conducting tubes.

As already stated, water necessarily has to be evaporated in enormous quantities in order that the needed chemical substances may be accumulated in a tree. Water also forms an important constituent in all tissues of a living tree. The approximate amount (in percentage) of water recorded for some of our shade trees under ordinary conditions will be of interest here: e.g., black locust, 28 percent; white ash, 30 percent; white cedar and black cherry, 36 percent; shagbark hickory and sugar maple, 37 percent; beech, 38 percent; white oak, 40 percent; red maple and loblolly pine, 41 percent; white pine, 43 percent; sweet gum, 45 percent; sycamore and red oak, 46 percent; American elm, 47 percent; aspen, 50 percent; incense cedar, eastern hemlock, and jack pine, 52 percent; cottonwood, 53 to 57 percent; evergreen magnolia and balsam fir, 54 percent; chestnut, 55 percent; and white fir, 61 percent. These figures still further emphasize the importance of water to a living tree.

Young trees that have been recently set usually need artificial watering at least for 2 or 3 years during dry seasons. Other trees often require it in order to keep them in a healthy condition, or to help overcome the effects of injury, disease, pruning, or cavity work. The amount of water needed varies according to local conditions, such as slope, soil, exposure, etc. As a rule the best results from artificial watering during a dry season will come from a copious watering not oftener than once or twice a week, rather than a little every day, but apparently this rule is not without exceptions.

To accomplish the most good the watering should continue until the soil surrounding the small feeding roots is throughly soaked. One simple way of determining this condition is to apply a considerable quantity of water (perhaps estimated by the time the water has been running) and, after allowing it to soak in throughly, dig a hole with a trowel or spade, and note the depth to which the water has penetrated. With most trees, under normal conditions, it should penetrate at least a foot at each watering. This will represent a much greater quantity of water than most people realize. It may be necessary to dig a second (or third) hole in order to determine when the requisite amount of water has been applied; if so, the second hole should be made at least a short distance from the first one, so as to determine the penetration of water through the previously undisturbed soil. Another watering should be given as soon as the soil becomes dry enough to crumble readily between the fingers. This may be from 2 or 3 days to 3 or more weeks. When the amount of water required to reach the roots has been determined for a certain place and also the time it takes for the soil to dry out again, the data will be available for roughly estimating the quantity of water needed, as well as the frequency of its application, provided all conditions under which the tests were made remain approximately the same. The water in the soil may be conserved by loosening the surface soil with a rake or harrow as soon as the surface becomes sufficiently dry to permit it after each watering, or by applying a mulch of straw, leaves, or other suitable material.

In certain situations, particularly where there is a sod or the soil is hard-packed or the surface area of dirt is very limited, as often occurs between the sidewalk and the street pavement or between walks and

walls elsewhere, one way to water the roots is to insert short tile drain-pipes vertically in the soil and turn the water into these. If this method is adopted, the tiles should be from a foot to 18 inches or more long and 2 to 5 inches in diameter, with the top practically at the ground level. The top can be kept covered when the water is not running, or the drain pipe can be filled with coarse crushed rock. It is usually unnecessary and undesirable to insert these pipes near the trunk; the best place is out beneath or beyond the ends of the overhead branches, as that is where the feeding roots are located in ordinary round-headed trees. Another and often better way to water the roots under such conditions is to use a crowbar to make holes 18 or 24 inches deep and about the same distance apart throughout and somewhat beyond the region of small feeding roots, or a spading fork can be used with good results to perforate a sod, just before watering.

AIR REQUIREMENTS

Air, more particularly oxygen, is as essential to plant life as it is to human beings, and for the same reasons. The process of breathing (respiration) is the same in both plants and animals, although the structures regulating the processes are different in the two types of organisms. Air must reach every part of a plant, including the root system. It must reach the interior of the plant. In most plants, including trees, it enters the interior through microscopic openings (stomata) mainly in the lower surface of the leaves, and through specially constructed areas of loosely arranged cells (lenticels) in the bark. These openings communicate with tiny labyrinthian air channels through the interior.

Like human beings trees may become sickly or die if the surrounding air (either above or below ground) contains an excess of noxious gases. They may be asphyxiated through inability to obtain oxygen, as is supposed to happen when the breathing areas in the bark are clogged by painting a considerable portion of the healthy bark with air-impervious oil, tar, or paint. Most trees may be suffocated (drowned) by a long-continued superabundance of water in the soil around the roots.

FOOD REQUIREMENTS

In the presence of sunlight and heat the tree manufactures its own food, mainly from water and its impurities taken in by the roots and carbon dioxide from the air. Water from the soil, with small amounts of various inorganic substances in solution, is absorbed by the root hairs and small roots, carried up through the sapwood of the root, trunk, limbs, twigs and through the veins of the leaves to cells containing the green pigment (chlorophyll). Here in the presence of light and heat the transformation from inorganic substances to organic food takes place. Some of the water that reaches the green leaves has its elements separated and recombined with carbon from the carbon dioxide of the air, to form ultimately such organic food substances as sugar and starch.

These newly formed organic foods are carried downward mainly through microscopic conducting tubes and cells in the inner bark to parts of the tree where growth is active. There they may be transformed into new tissues of the roots, twigs, leaves, wood, bark, flowers, fruits, etc., or if an excess is manufactured it may be stored in

various forms and at various points for future use. Starch and other newly formed solid foods necessarily have to be changed (digested by ferments) into soluble substances before being carried through the tissues to other portions of the tree.

Whenever a tree shows many dead limbs or twigs or whenever the tree has been treated for a considerable amount of disease or injury, it is advisable, and often essential, that fertilizers be applied to the soil so as to supply raw plant food and to stimulate growth. This is particularly important after extensive cavity work or pruning on the trunk or large limbs, and this treatment usually is very beneficial to all trees that are not in full vigor.

One of the best fertilizers for immediate effect is nitrate of soda, applied broadcast in the spring or early summer at the rate of 2 to 5 pounds for a medium-sized tree. The direct effect of this usually lasts for a year only, but the indirect effect may be apparent the following year. It usually stimulates the healing of wounds made by pruning or cavity work, and also the production of darker foliage. However, an excess, or an application late in the season, may cause injury or excessive development of leaves and failure to properly mature the new wood before winter. Sulphate of ammonia is even better than nitrate of soda except for securing immediate effect early in the spring. It is more slowly available and its effects are more lasting, consequently it is generally safer to use it in the middle of the summer or late in the summer. For oaks, most evergreens, and other trees that naturally thrive on an acid soil, unless the soil is very acid and quick stimulation is imperative, sulphate of ammonia is usually better than nitrate of soda.

A more lasting fertilizer is well-rotted manure worked into the soil at the rate of 10 to 20 cubic feet to 100 square feet of soil. Fertilizers need not be applied near the trunk, although usually they are not without benefit even there. They should be used in a circle just under and beyond the tips of the spreading limbs; say for a tree with limbs reaching 20 feet from the trunk, the fertilizers can be used to the best advantage in a circle ranging from 15 to 30 feet from the trunk. Under some circumstances it may be desirable to mix manure with the soil to a depth of 2 feet or more in a trench beginning at the tips of the spreading branches and running out for 10 or 15 feet beyond the tips of the branches. This general rule for locating the trench applies only to round-headed trees; for spiry trees have the inner edge of the trench about half the height of the tree from the trunk. It is not always possible or advisable to do this trenching in the manner described, but if the trench is placed nearer the trunk than indicated, there is always the danger of injuring the larger roots with the spade or fork if great care is not exercised. In some cases no particular harm appears to have resulted when the ends of the roots up to an inch in diameter were cut off cleanly, as this seemed to stimulate the formation of small feeding roots in the new soil in the trenched area.

A very good, economical method of introducing fertilizers into the soil—a method that does not seriously disfigure a well-kept lawn or a street parking strip—is to make crowbar holes as indicated on page 7 and fill these with the proper chemical or natural fertilizers, nearly to the top. A still better method is to drill holes through the sod to a depth of about 18 inches, insert the fertilizer, and force it through the soil under high air pressure. As this method requires an air compres-

sor, strong air tubes, and a specially constructed patent nozzle, it is not available for the novice. Some tree-surgery firms are equipped with appliances to do this type of work. In restricted areas such as parking strips along streets, treatments may need to be made more or less continuously to supply the needs of the trees in order to compensate for the limited ground space.

Raw bone meal is a good fertilizer for most trees, but is only slowly available. This is often an advantage. It usually stimulates fruit and seed production and does not seem to injure trees when used in considerable quantity. Lime in small quantity is usually beneficial to many trees, but is injurious to many others, especially those that grow naturally or preferably in an acid soil, for example, most oaks and pines, and black and red spruce, but not the white spruce.

A few excellent fertilizers containing stable or sheep manure, bone meal, and other necessary ingredients are on the market. As it is not easy for the novice to determine just what essential elements (if any) are lacking in the soil it will be simpler for him to use a fertilizer containing nitrogen, phosphorus, and potash, even though one or another may not really be needed.

CAUSES OF INJURY

PAVEMENTS AND OTHER URBAN CONDITIONS

Probably pavements directly or indirectly cause the ill health or death of more trees along city streets than any other one factor. Impervious pavements prevent rain water and air from entering the soil. Gas from leaky pipes or even gas from the tar or asphalt pavements cannot readily escape. Any or all of these conditions may cause ill health or death. Exhaust gases from automobile and other gas engines are known to be injurious or even fatal to human beings and animals, and there is evidence to indicate that such gases may be injurious to plant life also. The fumes and dust from oiled or tarred roads, fumes from smelter and chemical works, dust from cement works, and smoke are known to cause injury to nearly all forms of plant life with which they come in contact, if they are present in sufficient quantity.

Trees and shrubs often are scorched, burned, or otherwise injured by being located where whitewashed or light-colored walls reflect the heat of the sun. Too-dense shade, too-intense sunlight, or too-close planting is often responsible for certain types of injury.

Ice, snow, or wind may break limbs or uproot trees, which in turn may injure other trees as they fall. Horses frequently gnaw the bark of unprotected street trees. Telephone, telegraph, and electric linemen with their climbing spurs and saws are notorious mutilators of shade trees in towns where the trimming of trees is not regulated by law. Electric wires carrying a high voltage may discharge heavy currents through trees if the insulation becomes defective. Wheels of horse-drawn vehicles and automobiles frequently wound or tear away large pieces of bark.

LAWNS

Many ornamental trees are located in lawns or grass plots, locations that are not ideal for their best development. However, many trees appear to remain healthy under such conditions, and most of them will do so if the supply of water and food is sufficient at all times for

both tree and grass. If the supply of water for any extended period (sometimes for a period less than a month) is insufficient for both tree and grass, the former will generally suffer more permanent injury than the grass, unless there is some source of water supply in the subsoil. Particularly is this the case during dry seasons when the only available supply of water comes in the form of occasional light showers or artificial watering. Under these conditions the grass may take up practically all the water that falls and the tree continue to experience drought conditions. A short heavy rainfall, especially on sloping ground, seldom penetrates to the roots of the tree, as the sod appropriates the small amount that does not run off.

Perforating the sod with a manure fork or crowbar just before a rainfall or routine watering will greatly facilitate the passage of water into the soil beneath the sod. Under certain conditions of sod this may be the only practical way of readily wetting the roots of the tree without breaking up the lawn. However, there is great danger of injuring the roots with the fork or crowbar if it is used near the trunk or over large roots. The proper place to perforate the sod is out near and beyond the tips of the spreading overhead branches.

What has been said regarding the application of water to a grass sod applies equally well to fertilizers when applied broadcast. Owing to the fact that a dense mat of grass roots is nearer the surface than the tree roots the grass will be benefited by the application, while the tree roots may receive practically none. If fertilizers are intended primarily for the tree they should be placed beneath the sod by means of crowbar holes, as described on page 7, or, better for the tree, if circumstances warrant such extreme measures, the sod broken up, the fertilizer applied, and the ground left fallow for at least part of a year, and later resodded or reseeded. Measures of this kind must sometimes be used to save or improve the growth of street trees that grow under adverse conditions at best. The growth of annual crops or flowering plants beneath trees is usually beneficial insofar as it keeps the soil loosened and aerated and precludes the growth of grass sod; while the yearly application of fertilizers to the garden enriches the soil and, if manure is used, conserves its moisture. On most lawns it is customary to mow the grass and immediately rake up the clippings. If these clippings were allowed to remain they would serve as a thin mulch, and as they decayed the soil would be still further enriched. The practice of removing the clippings materially contributes to the impoverishment of the soil.

INSECTS

It is a matter of common knowledge that insects cause in many different ways an enormous amount of damage to trees. They also cause indirect damage to trees by acting as carriers for such diseases as the Dutch elm disease. However, as insect injuries to trees lie within the province of the entomologist, they will be considered in this bulletin only in a general way when they are associated with fungi in producing decayed areas in tree trunks and limbs. Readers who are specially interested in insects and insect injuries and methods of control are referred to the publications of the Bureau of Entomology of the United States Department of Agriculture and of the various State entomologists.

Damage done by such birds as woodpeckers in plugging holes in trees to extract insects lodged in or under the bark is discussed in publications of the Bureau of Biological Survey of the United States Department of Agriculture.

RODENTS

Rodents, such as field mice, pocket gophers, rabbits, and porcupines, may injure fruit and other trees. Information on these animals has been published by the Bureau of Biological Survey. Rodent injuries should receive treatment similar to that of other injuries. But in case of complete girdling of young and vigorous trees bridge grafting [1] may be used if the value of the tree justifies the expense.

FUNGI

Fungi are low types of plants, which produce no true flowers or seeds. They lack the green color pigment of ordinary green plants, and in consequence cannot manufacture their own food from the inorganic elements. However, in order to live and grow they require food just the same as all other plants and all animals. Because they cannot manufacture organic food they have to obtain it in other ways, by appropriating food that has already been manufactured by some green plant. When a fungus obtains its food from a living organism it is known as a parasitic fungus or a parasite; when from dead organisms it is known as a saprophytic fungus or a saprophyte. Fungi, like other plants, have a vegetative or growing stage and a fruiting or reproductive stage. In ordinary green plants the roots, stems, and leaves represent the vegetative stage, and the familiar flowers and fruits represent the fruiting stage. In fungi the vegetative stage is composed of microscopic threads (hyphae) which grow in or on living plants or animals, or in or on dead and decaying plant or animal matter, from which they absorb the necessary organic "ready-made" food. The vegetative mass of threads is known as the mycelium and in bulk may be visible to the naked eye, as, for example, the familiar cottony mold on fruits. However, this stage of a parasitic fungus usually is not seen by the ordinary observer because it commonly occurs only within the tissues of the living plant or animal (known as the host) from which it obtains its food.

The fruiting stage of a fungus is more familiar to the layman than is the vegetative. Mushrooms, toadstools, puffballs, etc., represent the fruiting stages of certain fungi. Most fruiting bodies of this particular sort occur on leaf mold, dead logs, or other decaying organic matter, but certain species occur on living trees. Fungus fruiting bodies occur in a great variety of other forms, colors, and sizes. At maturity each of these fruiting bodies commonly produces innumerable microscopic reproductive bodies (spores), each of which may produce a new fungus plant under favorable conditions. The dust-like cloud which arises from a mature puffball when it is tapped is composed almost entirely of such spores. It is obvious from what has been said that the prompt destruction of young fruiting bodies before they mature their spores is of vital importance in preventing the spread of the fungus, just as the destruction of the annual weeds

[1] Farmers' Bulletin 1369, Bridge grafting.

before they mature their seeds is one of the most important factors in their extermination.

Other facts concerning fungi that should be kept in mind in connection with the treatment of tree wounds are: (1) A fungus rarely produces a fruiting body until it has a well-developed vegetative stage to supply it with food; consequently when a fungus fruiting body appears on a tree (or elsewhere) it means that a well-developed vegetative stage has existed for some time and is still present. Although it may not be seen by the naked eye unless massed, its hyphae are, nevertheless, growing through the tissues of the host. (2) Usually a mere fragment of a single hypha remaining in the wood will continue the fungus vegetatively. (3) The area of active growth of the vegetative stage of the fungus can sometimes (but not always) be known by its effect on the wood or bark. This often is discolored, waterlogged, sunken, swollen, decayed, or hollow. (4) All of this vegetative stage must be removed or killed in order to stop further possible decay or disease. (5) If a fungus fruiting body is left on the tree the disease may be spread readily to other trees or to other parts of the same tree. Also it means that there is a considerable portion of the vegetative stage still growing in the tree and capable of increasing the area of the disease after the fruiting body is removed.

Fungi cause many diseases of trees, but, what is of more immediate importance in connection with injured trees, they also cause decay of the wood, particularly in the immediate vicinity of wounds. If unchecked this decay may eventually so weaken the tree that it will break in a heavy wind. Failure to properly treat freshly made wounds causes needless expense in later years if attempts are then made to counteract the ravages of fungi causing the decay. Organisms of decay work mainly in the woody portions of a tree, gaining entrance through injuries and neglected wounds of various sorts and extending up and down the interior of the trunk, often for long distances. They usually continue their work of decay indefinitely or at least until the infected areas are properly cared for as indicated on page 24. Hollows or diseased spots in trees arising from external injuries are familiar sights. In most cases they have been caused by fungi that were allowed to grow for years with little or no attempt being made to check their ravages. Trees along streets and highways need regular inspection for such conditions to prevent their becoming hazards to traffic.

MISTLETOE

In the Southern and Pacific States mistletoe is a common pest of many shade trees, producing on the tree branches globular masses from a few inches to several feet in diameter. Mistletoes are parasitic flowering plants that obtain their food by sending rootlike "sinkers" into the tissues of the tree and sucking up food that has already been manufactured by the green portions of the tree. If mistletoe is in great abundance it is a distinct menace to the host tree and in extreme cases may kill it. The complete eradication of mistletoe involves killing the "sinkers" or removing them by pruning. However, mistletoe usually can be kept under control by breaking off the brittle growths every year or two with a long pole or other suitable implement.

PREVENTION BETTER THAN CURE

Preventing the formation of a pocket of decay or preventing a disease from getting started on a tree is far better and much more economical than trying to cure either in later years.

If trees are located along driveways or streets, or in other situations where horses can easily reach them, they should be protected by tree guards. If a limb is so located that it crowds or rubs another, one of them usually should be removed. Cut out the one that is least essential to the tree, from whatever standpoint is considered most important, such as size, vigor, location, symmetry, etc.

Although the remaining pages of this bulletin are concerned mainly with pruning and cavity work, the significant fact should always be borne in mind that proper feeding and watering of diseased, decayed, or otherwise weakened trees often are of much greater importance. It usually is an excellent rule to feed all trees that have been subjected to much pruning or cavity work, in order to stimulate prompt callus formation over the edges of all wounds, and it is quite essential to do so in the case of weakened trees.

If injuries remain untreated, decay may penetrate into the interior of the tree and increase from year to year until large limbs, or the trunk itself, become so weakened that they break in a violent wind. It requires comparatively little time and money to clean and paint a freshly made injury. It often requres much time and money to treat properly the same injury after it has been neglected for a few years. Moreover, an injury promptly treated will heal and cover the scar more quickly and effectively. Almost every large decayed area has resulted from an injury that would have required comparatively little time and effort to clean, sterilize, and dress at the time it occurred. The most economical and effective method of preventing a decayed area in a tree is to attend to the injury that may eventually give rise to it as soon as the injury occurs, perhaps 20 or 30 years before it would become a real menace to the tree. This fact should be remembered by tree owners and persons charged with the care of trees. If acted upon, it may mean an ultimate saving in later years of many hundred percent in the cost of keeping the trees in good condition.

Practically all cavities might have been prevented if the original injury had been properly treated as soon as it occurred, so that the healing tissues could have grown over the sterilized and protected wound. Because this has not been done to any extent in the past, a demand has been created for tree-surgery methods—methods which often cost today, through past neglect, many times the amount that it would have cost to forestall the decay 10 or 20 years earlier. Moreover, an injury promptly treated might today be entirely or relatively inconspicuous. Neglect for 10 or more years means that the decayed area will be conspicuous and unsightly for years to come, if not during the entire remaining life of the tree.

WHAT TREES ARE WORTH TREATING

Most shade and ornamental trees with only a few dead limbs are unquestionably worth attention. Others that have many dead limbs or decayed areas may not be worth the expense, particularly if they are rapid-growing short-lived trees. This point should be considered very carefully before any work is undertaken. Under no circum-

stances should a badly diseased or insect-infested tree be allowed to remain as a menace to nearby trees that are in a more healthy or entirely healthy condition. All diseased or insect-infested bark, wood, or leaves should be removed and all freshly cut surfaces properly treated, or the entire tree should be removed. In most cases the diseased portions should be burned immediately; in case of doubt as to the contagious character of the diseased portions, it is better to err on the safe side and burn them. No one can decide better than the owner whether a tree is worth the expense of trying to save it, because the actual commercial value of an ornamental or shade tree usually has nothing to do with the decision. It is generally a question of esthetic value, or historic associations, or rarity of species, or location for shade. A man who has had experience in caring for mutilated or diseased trees may be able to say definitely whether it is possible to prolong the life of the tree, but the owner, who has to do the work or pay the bill, is the one who will have to decide whether the tree is worth the expense of treatment. Often the owner will be better satisfied in the end to have a badly diseased or mutilated tree replaced by a healthy, perfect one. In expert hands the moving of comparatively large trees is no longer a hazardous undertaking, although it may be expensive.

WHEN THE WORK MAY BE DONE

Tree work has heretofore been undertaken at almost any time of the year when the sap has not been running too actively and the weather has not been too cold. In view of the fact that the plugging of the tubes in the water-conducting tissues by means of organic gums takes place primarily only during the actively growing season, it is quite likely that experience and authentic records later will show that the best time for major pruning and cavity work will be during May, June, July, and August, and the next best time in September and October, for the Northern States; and for a somewhat more extended period in the Southern States. Extensive cutting of trees should be avoided during the "bleeding" season. In most trees this will mean only during the time the buds and leaves are expanding in the spring. Freezing weather may injure cement work before it is fully set. Fillings composed largely of tar or asphalt are harder to handle in cold weather. These facts may have some bearing on the time selected for doing the work. They are important in making up schedules for maintenance and operating crews on public and semipublic projects.

TREATMENT

THE MOST IMPORTANT OPERATIONS

In the following pages will be found directions for treating injured trees, and portions that are decayed or diseased. Several different methods usually are described so that a choice can be made, dependent upon circumstances or necessity.

By far the most important operation is to treat all injuries as soon as possible. All splintered or loose wood and bark should be removed with a sharp cutting instrument and the cut edges shellacked, and, a day or two later, the whole wound properly dressed, as described below.

When a wound has developed an area of decay, all of this should be removed and the cavity treated the same as any freshly made wound.

If decay has progressed for some years it may be impossible to remove all of the fungus causing it without so weakening the tree that it will be a menace to life and property. This is one of the penalties of not attending to injuries as soon as they occur. If all the decayed tissues are not removed the fungus may continue its work of destruction.

In treating tree wounds a few fundamental principles must be observed, in order to secure permanently good results. These may be summarized briefly as follows:

(1) Remove all decayed, diseased, or injured wood or bark. When it is on a limb this can often be done best by removing the entire limb; if it is on a large limb or on the trunk it may be necessary to cut out the decayed matter, leaving a cavity.

(2) Sterilize all cut surfaces. This may be omitted if a good sterilizing dressing is used. (See item 3.)

(3) Protect all cut surfaces from external moisture and other injurious external agencies by also applying a more permanent dressing over the sterilized surface.

(4) Leave the work in the most favorable condition for rapid healing; this may sometimes necessitate filling deep cavities.

(5) Watch the work from year to year for defects, and if any appear, repair them immediately.

The simplest type of work consists in removing dead or dying limbs or neglected or decayed stubs and in treating the wounds so as to prevent the entrance of decay-producing organisms and moisture while the healing is taking place. A more complicated type consists in digging out decayed and diseased wood and treating the freshly cut surfaces of the cavities as described later (p. 24), and sometimes in filling the cavities with suitable material. The artificial filling of an ordinary cavity does not usually increase the strength of the trunk or limb. An improperly filled cavity is probably always a menace to a tree.

SOME THINGS TO BE AVOIDED

The careless use of a long pruning hook or other implement to break off small dead twigs should be avoided, as every bruise may become the point of entrance of disease or decay. Climbing spurs produce wounds that are very easily and frequently infected. Spurs should never be used except on a tree that is soon to be removed or destroyed. A man who insists on using climbing spurs in tree-repair work should never be allowed to work on trees. Nails and hard leather soles and heels on shoes often cause injury. Rubber-soled tennis shoes, or "sneakers", or some similar soft-soled shoes that will not slip should be worn when it becomes necessary to climb a tree.

Limbs or trees should never be guyed by passing wires, chains, or ropes tightly around them. These may eventually strangle the portions above the encircling band. Encircling fence wires, telegraph wires, or clotheslines may act in the same way, killing all parts of the tree beyond the ligature if they remain tightly drawn around the limb or trunk for any great length of time, often in less than a year.

GUYING AND BRACING

Closely associated with tree-repair work, and often really a part of it, is the guying and bracing of limbs to prevent the splitting of the crotches or to check splitting that has already started.

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A simple method of bracing a crotch is to put a hook or eyebolt through each limb, with the hooks or eyes toward each other and from 3 to 10 feet or more above the crotch (depending upon the size, position, and length of the limbs), and to tie these hooks by means of a strong wire, wire cable with thimble and clips at the ends, or chain (figs. 2 and 3). Three or more adjoining limbs may be guyed collectively. The precautions mentioned on page 28 should always be followed, so far as they apply to boring and tarring the hole and countersinking the washers of the bolts. On smaller limbs heavy coarsely threaded screw hooks or screw eyes can be substituted for the bolts.

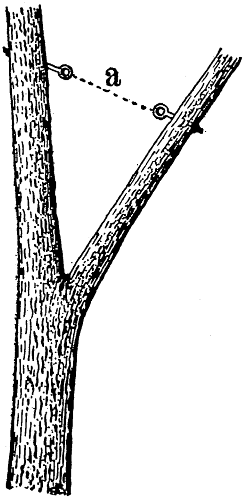

FIGURE 2.—Side view of limbs, showing the proper method of guying them above a weak or split crotch. The wire, cable, or chain guy is shown at *a*.

A turnbuckle in the rod, bolt, cable, or wire guy will be of use in keeping it taut at all times, as this permits a ready tightening of the guy within certain limits, should it later become advisable to do so. If a very taut guy is desired one end of a heavy wire (e.g., a telegraph wire) can be securely fastened to one eyebolt, looped through the second eyebolt, drawn up as tightly as convenient, and the free end securely fastened at the first eyebolt, leaving a guy composed of two wires. An iron bar placed between the wires can then be used to twist them as much as desired, thus shortening the guy and drawing the two limbs more closely together. This simple device can often replace a turnbuckle guy.

If for any reason the guy is to be placed within a foot or two of the crotch, a single long bolt or screw rod can often be used to better advantage, and sometimes a single long bolt or screw rod with a swivel can be used in place of a cable, a chain, or a turnbuckle rod where the guyed limbs are not likely to twist much as they sway in the wind. If one or more bolts are to be used through, or above, a split crotch, follow the detailed directions given on page 27. More complicated types of bracing may well be left to a reliable commercial tree surgeon who is specially trained for this sort of technic.

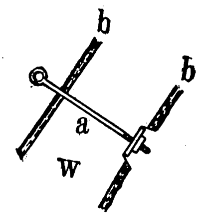

FIGURE 3.—Sectional view of the limb in figure 2, showing the details of placing an eyebolt of the type shown in figure 2: *a*, Bolt; *b*, bark; *w*, wood.

Occasionally it may become necessary to guy a whole tree in order to prevent the breaking of the trunk when an unusually large cavity leaves only a thin shell of sound wood, or to prevent a tree that has recently been set from tipping over before its roots have become well established. This can be accomplished by attaching four guy wires or ropes to the tree about half way from the ground to the top of the tree and having these slant downward at an angle of about 45° to four stout posts set firmly in the ground about equidistant around the tree (e.g., on the north, east, south, and west sides of the tree). If the guying is for temporary purposes only, two broad bands of leather or stout canvas or other strong material, each long enough to make a

loop at least twice the diameter of the trunk or limb to be encircled and 4 to 6 inches wide, may be passed around the tree or some favorably situated limb and two adjoining guys attached to each loose loop. If a permanent guying is needed, two eyebolts (or hookbolts) can be placed through parallel creosoted holes in the trunk or limb about halfway up the tree, one 6 inches or more above the other. The eye of one bolt should be on the opposite side of the tree from the other. Two guys from two adjoining posts are attached to each eyebolt, the latter pointing halfway between the two posts to which the guys are to be attached (fig. 4). The chafing of a limb against a guy should be prevented by padding the guy wire with a piece of garden hose or the limb with burlap, provided the guy cannot be so placed or braced as to clear all limbs. A piece of an old automobile tire may often be used effectively.

REMOVING BRANCHES

The removal of healthy, broken, dead, or diseased branches when the cut is made entirely through healthy wood comprises two essential operations: (1) Removing the branches in a manner that will prevent injury to the surrounding bark and cambium and leave the wound in the most favorable condition for prompt healing; and (2) sterilizing, shellacking, or otherwise protecting the scars against infection. If decay runs back into the trunk, a third step is necessary. All decayed matter should be excavated, following the directions given under Cavity Work (p. 24).

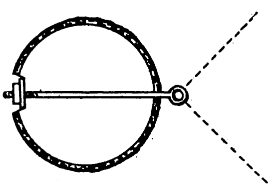

FIGURE 4.—Sectional view of a tree trunk, showing the details of placing bolts for permanently guying a tree to the ground. This method of placing a bolt is used also in guying three or more limbs together. The broken lines indicate the guy wires.

The most useful implements for removing large branches are a good-sized saw with teeth so set as to make a wide cut, a gouge, a chisel, a mallet, and a strong sharp knife. An oilstone is needed for sharpening the tools. For cutting limbs near the ground, these are the only necessary implements, although others may often be convenient.

For work higher up in the tree ladders or ropes may be needed. If the work is to be done from the ladder, the top should be securely tied or otherwise fastened to the tree so it cannot slip. Most tree workers have practically abandoned the use of ladders except to get up to the lowest branch of the tree, ropes being thrown over limbs higher up, both for assistance in climbing and for support for the workman below, or to enable him to swing from one portion of the tree to another. A light one-pole scaling ladder similar to that used by firemen will sometimes be handier than the ordinary heavier two-pole ladder. This can be hooked over limbs at different heights and used to facilitate fastening the ropes. If a scaling ladder is used, the hook should be well padded with some soft material to prevent its bruising the bark. If the workman wears a heavy belt with a strong snap hook attached to it, similar to that used by electric linemen when working on a high pole, and has this hook snapped into a loop at the lower end of a rope securely attached to an overhead branch, a fall may be prevented.

After a severe ice or wind storm all broken and hanging branches that are a menace to life or property should be removed promptly, generally by being cut at the break. A general survey of the condition of the tree should then be made in order to learn whether injuries are too numerous or extensive to warrant attempting to save it. If an attempt to save the tree seems warranted, and the tree is badly smashed, some or all of the main stubs (after the splintered ends have been trimmed off) may be left until growth starts sufficiently to show where vigorous buds or shoots will develop. The ends of the stubs may then be removed with a slanting cut starting just above a vigorous bud or shoot and running back and across the limb at an angle of about 45°, and the scar properly treated. The developing bud or shoot must be at the peak of the slanting cut.

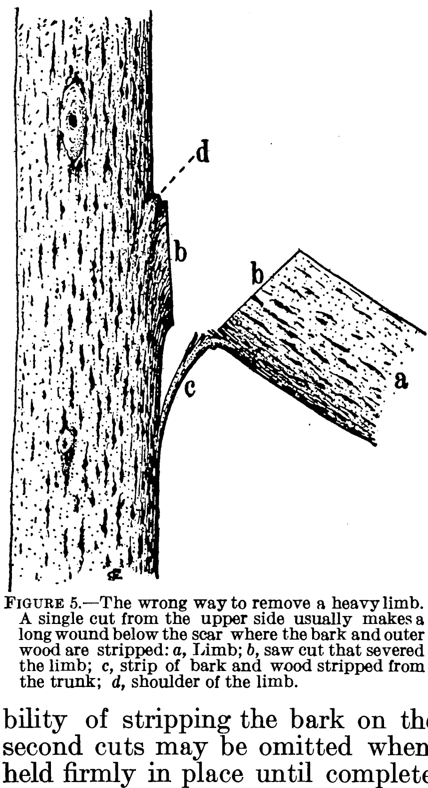

FIGURE 5.—The wrong way to remove a heavy limb. A single cut from the upper side usually makes a long wound below the scar where the bark and outer wood are stripped: *a*, Limb; *b*, saw cut that severed the limb; *c*, strip of bark and wood stripped from the trunk; *d*, shoulder of the limb.

A large limb should rarely be removed by a single saw cut from the upper side, as this usually strips the bark and wood below the scar as it falls (fig. 5). A preliminary cut should be made on the under side, usually from 6 inches to a foot beyond the point where the final cut is to be made. It should reach from a quarter to half way through the limb (fig. 6, *a*). A good time to stop is when the saw becomes pinched in the cut. A second cut should be made on the upper side of the limb, an inch or more beyond the first one (fig. 6, *b*) and continued until the limb falls. A third cut, to remove the stub, should then be made close to the trunk (fig. 7, *c*). When nearly severed the stub must be supported so as to avoid any possibility of stripping the bark on the trunk as it falls. The first and second cuts may be omitted when a limb is so small that it can be held firmly in place until completely severed. If desired, the edges of the scar may be smoothed with a sharp chisel to conform to the trunk. A flat cut of the type described will usually heal over with a depressed place in the center. This is sometimes objectionable. In attempting to counteract this tendency some tree workers leave a slightly conical or convex scar, the center being an inch or more higher than the margin for a scar 6 inches in diameter, and proportionally higher in larger scars. All final cuts should be made so as to allow rain water to drain off readily.

A large limb often can be removed safely with a single downward saw cut close to the trunk if handled as shown in figure 8. The object of the rope or prop is to lift the base of the limb as it falls, thus causing the splinter of bark and wood to be stripped from the branch instead of the trunk. This splinter attached to the trunk is then

sawed off. It is bad practice, as well as a menace to the tree, to leave a projecting leafless stub (fig. 9) as such a stub will almost always die back close to the trunk or supporting limb and into the heartwood if left untreated. The scar should be pointed at both ends (fig. 10), as this is the most favorable shape for satisfactory healing. If the cut has not been made through perfectly healthy wood, the wound should be cut back until sound healthy wood is reached.

A good coat of shellac varnish [2] should be applied with a suitable brush over the entire cut edge of the bark, the adjoining outer sapwood, and the cambium, immediately after the cut is made, or at least as soon as the cut surfaces are sufficiently dry to allow the shellac to stick securely to the wood. This is to prevent any appreciable drying out and consequent dying back of the cambium. Shellac is merely a temporary dressing, although it is a very important step in the repair process (p. 14). Usually it is unnecessary to shellac more than half an inch on either side of the cambium. If the scar is a large one, a sharp knife or drawshave should be used along the margin for 1 or 2 minutes, and then the freshly cut surfaces shellacked, the operation being repeated until all the bark and outer sapwood encircling the scar have been shellacked. The maximum benefit from shellacking is not likely to be realized if the freshly cut surface is allowed to remain dry and without shellac for more than 3 or 4 minutes. The shellac brush can be cleaned readily at any time by working it around for a few minutes in a can of water in which a little borax has been dissolved. It is then rinsed in clear water and dried before being used again. The shellac can be conserved while in use by having the handle of the brush fitted tightly through a hole in the cover of a friction-top can, and leaving the cover on the brush when it is used to spread the shellac.

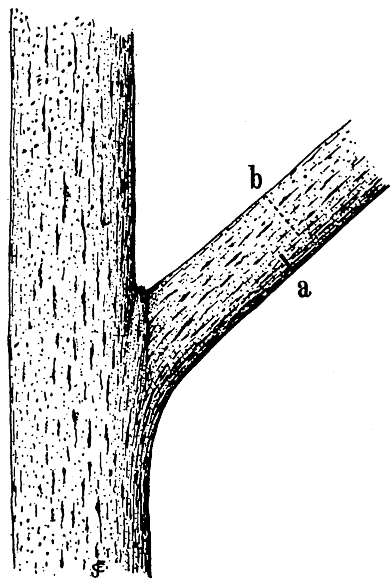

FIGURE 6.—The right way to remove a heavy limb. The first cut is made on the under side of the limb at *a*. The second cut is made at *b*, and is continued until the limb falls.

A mixture of 4 parts asphaltum and 1 part of paraffin applied warm is used in place of shellac to protect the freshly cut cambium in some western orchards and is highly recommended for that purpose by those who have used it.

For the work of removing small branches, either a saw, a sharp strong knife, a hand pruner, a chisel, or a long pruning hook may be used, as seems most suitable. In skillful hands a small sharp hand

[2] The shellac varnish should be made up in accordance with Federal Specifications Board specification no. 376. In brief, this is, stick lac "cut" in 95-percent specially denatured alcohol, formula no. 1 of the U.S. Internal Revenue Bureau (i.e., 100 parts ethyl alcohol and 5 parts approved wood alcohol).

ax may be used to greater advantage. In removing small branches and twigs the cut should be made as close to the surface of the supporting branch as possible, so as to leave no projecting stub (fig. 9). A sharp knife, used in an upward cut, is the best tool for the work and should be employed, when possible, in preference to the hand pruner or pruning hook. When the hand pruner is used the cutting blade should always be turned toward the tree, so that the supporting bar makes its bruise on the part that is cut away. The long pruning hook should be used with caution, and only when the place to be pruned cannot be reached with the knife or hand pruner.

For protection against possible infection, the pruning wounds must be treated in much the same manner as recommended above for those on larger branches. For covering the very small wounds no more permanent covering than shellac may be needed. Liquid grafting wax is particularly satisfactory for scars less than a half inch in width on choice trees or shrubs, or on scars that are susceptible to injury from the use of tar or creosote. In resinous trees the exuding resin, if well smeared over the cut, will usually give ample protection against the entrance of decay-producing organisms.

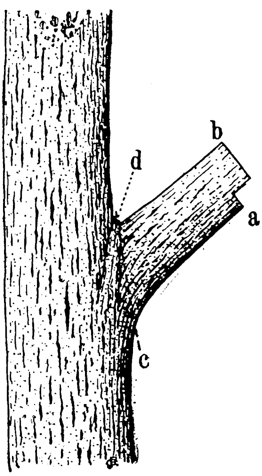

FIGURE 7.—The right way to remove a heavy limb. The third cut is made close to the trunk so as to leave no projecting stub. Both *a* and *b* are the same as in figure 6; *c* indicates the position of the third cut; the shoulder of the limb is shown at *d*.

The statement has often been made, and very widely accepted, that it is unnecessary to paint the scars made by cutting small branches a half inch or less in diameter; but the writer has observed many instances in which serious diseases have gained entrance through wounds that were considerably less than half an inch across. For thorough and careful work, particularly on choice trees or shrubs, the smaller scars should be as thoroughly treated as the larger ones. Care should be taken, however, that waterproof and airproof coverings are not applied to the surface of the uninjured bark adjoining the wound, or injury may result. Small untreated scars near the tips of small branches are not ordinarily a source of great danger, for if infection takes place it usually is possible to cut off the small limb farther back without seriously disfiguring the tree.

It sometimes is desirable to alter the shape or to reduce the size of the crown by pruning. When the trunk, or a crotch, is much weakened by decayed heartwood, or by much cavity work, it often is necessary to prune back heavily all the main branches, so as to materially reduce the size and weight of the crown. By so doing its weight is reduced, but what is of even greater importance, there are no long limbs left to exert their tremendous strain on weakened trunk or crotches when the wind blows. Trees pruned in this manner usually produce a smaller, well-rounded, and compact head in a comparatively few years. This type of pruning is common in Europe and in the drier regions of our own Southwest, but rarer in the eastern part of the United States, although it has been used with excellent results in the Arnold Arboretum. Under certain conditions, notably when the

trunk is small, hollow, or otherwise weakened, it is the only type of pruning that should be considered. Street and roadside trees should be pruned in such a way as to preserve their general normal outline as nearly as possible. Pruning also is commonly employed on fruit trees to stimulate fruit production.[3]

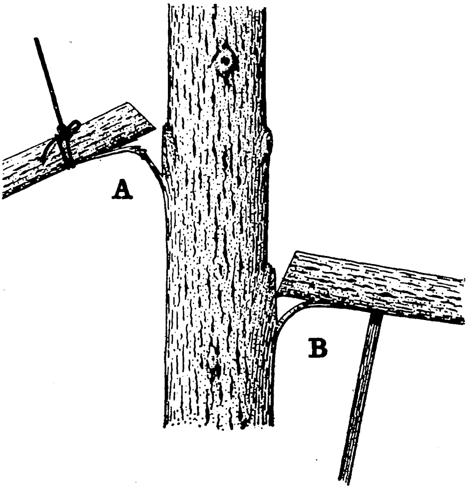

FIGURE 8.—A heavy limb can often be removed safely with a single downward saw cut if the limb is supported with a tightly drawn rope, as shown at *A*, or by a firmly placed heavy prop, as shown at *B*. This causes the end to lift as the limb falls. Both rope and prop should, if possible, be so slanted as to cause the limb to swing away from the trunk as it is severed. If the rope is tied to a living overhead branch, the latter should be well padded to prevent injury.

STERILIZING AND DRESSING WOUNDS

The ideal dressing for a wound is yet to be discovered. Many antiseptic and sterilizing preparations have been used with more or less success, but no dressing known has proved reasonably efficient unless the work has been carefully followed up from year to year and defects that appeared promptly repaired. Ordinary commercial creosote (a coal-tar product, sometimes called creosote oil) apparently is one of the best preparations for destroying and preventing the growth of wood-destroying fungi. It can be applied to a tree wound with an ordinary paintbrush and should cover every part of the exposed wood that has not already been covered by the shellac. The entire shellacked and creosoted surface may then be painted with thick coal tar or asphalt. For applying clear hot asphalt use a cloth swab or a brush made of broomcorn, as the bristles of an ordinary brush usually are soon destroyed if the asphalt is very hot.

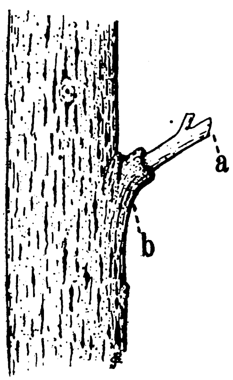

FIGURE 9.—A projecting stub of decaying wood which has become a menace to the living parts adjoining. This limb was cut at the point marked *a*; it should have been cut at *b*.

A single application of a mixture of creosote and coal tar (about one fourth or one third creosote) to cover the entire scar has been extensively used with good results. A better dressing is made by mixing melted asphalt with an equal quantity (by weight) of creosote. *As creosote is inflammable, care should be taken that it does not come in contact with an open flame.* A good way to mix the two ingredients is to melt the asphalt, then remove it from the heater and thoroughly stir in the necessary amount of creosote. If the mixture is too thick to apply when cold, reheat it and stir in more creosote. Asphalt without creosote (p. 31) is one of the best coverings and doubtless would be more generally used were it not necessary to apply it hot. A prepared

[3] See Farmers' Bulletin 181, Pruning.

emulsion of asphalt and water can be obtained in the open market. This preparation is excellent for wounds and can be applied in the same way as ordinary paint. It does away with the necessity of heating the preparation and after a few hours the water largely evaporates and leaves a coating of practically pure asphalt. The brush used to apply it soon becomes stiff, unless kept in water when not in use. Instead of a brush, a cheap, easily made swab can be used and may be discarded later. Paint alone frequently is used for a dressing but is less effective.

The creosote and tar mixture at times will cause injury when used around wounds on certain trees, especially cherries, peaches, and plums. Except on magnolias and tuliptrees, such injury has not been especially noticeable on most of our common shade trees. If injury from the use of this dressing is feared, a moderately blue solution of copper sulphate in water, or 1 part of corrosive sublimate in 1,000 parts of water, may be used as an antiseptic wash. The copper-sulphate solution is composed of 1 pound of copper sulphate (bluestone or blue vitriol) in 3 or 4 gallons of water. *Corrosive sublimate (or bichloride of mercury) is a deadly poison to man or animals if taken internally and is a caustic or corrosive agent on the skin or on metals.* The 1 to 1,000 solution can be made most readily by purchasing the 7- or 7.3-grain tablets of bichloride of mercury at a drug store, where they are sold subject to laws governing the sale of poisons. One of these tablets dissolved in a pint of water will make a solution of the proper strength. The solution should be freshly mixed for the best results. Usually it will retain sufficient strength for ordinary use for 2 or 3 months. If placed in an amber or blue bottle away from the light, it will keep at least 2 or 3 times longer. As a precautionary measure against the accidental poisoning of domestic animals, the discarded solution should be buried rather than poured into a sink drain or thrown out on the surface of the ground. Solutions should not be kept in metal containers, nor should brushes with metal coverings or wire-fastened bristles be used for applying it, as the solution promptly corrodes all metals with which it comes in contact. As soon as the antiseptic wash is dry the wound can be painted with any good lead paint, or even spar varnish. Grafting wax (particularly thick liquid alcoholic grafting wax) is excellent for treating small surfaces.

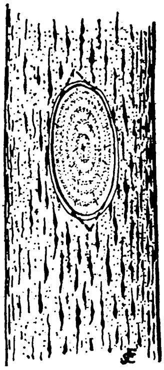

FIGURE 10.—If the shoulder has been removed and the upper and lower ends of the scar are broadly rounded or square they should be pointed, as indicated by the broken lines. If the shoulder (figs. 5, *d* and 7, *d*) has not been removed the pointing of the scar is not so important, and at times it is unnecessary.

Some tree workers treat large scars by charring the surface with a gasoline or alcohol blast torch and then quickly covering the hot surface with heavy tar, pitch, or hot asphalt. Heat is an excellent sterilizing agent, but it kills back the cambium considerably. Healthy trees that have wounds caused by very recent fires usually require no further sterilization. A good treatment for such trees is to scrape off most (but not all) of the charred wood and dress the wound as indicated in this section.

On particularly choice trees, where the black color of tar or asphalt is objectionable, the scar can be sterilized with the corrosive sublimate or copper sulphate solution and, as soon as dry, shellacked. When

the shellac has hardened it can be covered with spar varnish. For many purposes and on many trees this treatment is particularly satisfactory. If the scar is clean and healthy and not located near any former area of decay or disease, the sterilizing washes may be omitted and the shellac applied directly to the unsterilized scar. The alcohol in the shellac is a good sterilizing agent. If it is desirable that the scar be colored to match the bark, a suitably colored coat of paint can be applied over the shellac and allowed to dry before the coat of spar varnish is applied, or the spar varnish may be omitted.

In some western orchards good commercial bordeaux paste, mixed with sufficient water to allow it to be handled like thick paint, has been quite extensively used with good results but is recommended for temporary purposes only by those who have used it. Apparently it has the advantage of being air-porous but the disadvantage of weathering away rapidly. Moreover, it is poisonous if taken internally and consequently might be a source of danger if used where children or domestic animals could easily reach it. Another preparation still more highly recommended for use in western orchards is a thoroughly stirred mixture of bordeaux powder and raw linseed oil in proper proportion to make a thick paint. Ordinary commercial water glass (sodium silicate), in the proportion of 3 parts of water glass to 1 of water, is another preparation that is being used, particularly in the Middle States, as a wound covering. Although at present it gives some promise of becoming useful under certain conditions, the extent of its usefulness and its limitations apparently have not yet been satisfactorily demonstrated. Both bordeaux mixtures and the water glass are mentioned here merely as promising possibilities which need further testing to prove their worth for shade-tree work.

Permanently good results can be assured only when the dressed surfaces are watched from year to year and recoated annually or biennially, especially when any tendency of the coating to blister, crack, check, or peel is observed. This is a very important part of the work, a part that is commonly neglected. It is best to recoat the wounds regularly every year, even though no cracks or blisters appear. Blistered or loose portions of dressings should always be removed just before repainting.

Weather checks or cracks appearing in the wound must be treated immediately, in order to prevent possible reinfection. If these cracks have been neglected for a time and are sufficiently wide (one sixteenth of an inch or more) to permit them to be sprayed or washed with a sterilizing fluid, this should be done, and the surface repainted. If the cracks are too wide for the new dressing to bridge easily, they may be filled with sawdust and tar, or even with cotton dipped in tar or creosote, which is pushed into the crack with the point of a trowel or putty knife before the wound is redressed.

The healing of wounds by means of new callus growth at the sides is often more rapid if neither paint nor other generally used waterproof covering is applied (shellac excepted). However, the rapid healing of a wound is of secondary importance to preventing the entrance of decay-producing organisms. To prevent, check, or remove decay is one of the most important and essential considerations in the treatment of injured trees. It is of vital importance in the case of long-lived trees. With short-lived trees it obviously is of relatively less importance.

One of the best (though little-used) methods of counteracting the danger arising from cracks in large flat scars, particularly scars that are sound and healthy, is to cover the freshly dressed wood of the wound with heavy tarred paper, or, better, heavy cloth, firmly tacked to the wood and painted. The cloth should be cut slightly smaller than the scar, so as to leave about one eighth of an inch between the edge of the cloth and the cambium. This edge should be firmly tacked down in a manner that will make it impossible for the growing callus to push underneath the edge and lift the cloth. In resinous trees the exuding resin usually makes a good and sufficient dressing to smear over the wound before the cloth is applied.

CAVITY WORK

Cavity work in a tree involves cutting out decayed wood. As already stated, it often is impossible to get all the decayed matter out without so weakening the tree that it may become a menace to life and property, unless the crown is materially reduced by pruning. Many private and commercial workers recommend filling the cavity. A filled cavity that was not properly cleaned and dressed before being filled is of doubtful value. A filling serves mainly to force the new growth of wood and bark across the cavity.

When an injury or wound (except one naturally protected) has been allowed to remain untreated for a year or more, wood-decaying organisms almost invariably produce an area of decay beneath the exposed surface of the wood. If untreated, this area increases in size and depth until it may so weaken the limb or tree that a storm will break it at the weak point, or the decay may have developed to such an extent that any attempt at treatment would be a waste of time and money. Such areas of decay often are aggravated and increased by the presence of insects, particularly borers and ants. All such regions of decay, if they are treated at all, should be attended to promptly for best results. Irrespective of the size, age, or location of the decayed or diseased area, the first steps toward checking it are practically identical in all cases. They may be regarded as comprising two essential operations: (1) Excavating decayed and diseased wood, and (2) sterilizing and dressing cut surfaces.

The necessary tools for digging out the decayed wood are few. As a rule, two outside-ground socket-handled gouges, a chisel, a mallet, a knife, and an oilstone are sufficient for ordinary work. One gouge should have a curved cutting edge of about an inch, and the other one of perhaps 1½ or 2 inches. A smaller and stouter gouge may have to be used in trees that have very hard wood, e.g., live oaks, etc. The gouge, chisel, and knife should never be used on the bark or near the cambium when they lack a keen edge, as dull tools may easily injure the latter. In cutting out deep cavities, longer interchangeable handles for the gouges may be necessary. A ladder or a stepladder may be required if the work is more than 5 or 6 feet from the ground. As the work progresses, the desirability or convenience of having certain other implements will often become evident.

EXCAVATING

One of the fundamental principles in controlling disease (whether of animals or plants) is to remove, destroy, or render harmless the organism causing the disease. Decay or rot in trees is caused by

various specific organisms. These must be removed, killed, or otherwise rendered harmless, in order to stop the progress of the decay. In trees the diseased tissue is usually removed by cutting. But cutting out the decayed tissue alone is not sufficient. All wounds must be protected against reinfection and, what is equally important, cracks that appear as a result of surface-drying after the work is completed must be plugged or covered as indicated later, for reinfection of wounds may take place in these cracks.

Usually an old neglected area of decay is partially or wholly covered by a comparatively recent growth of wood and bark around the edges, and the visible portion may be comparatively small (fig. 11). In such cases it often is necessary to enlarge the opening, in order to have sufficient room in which to gouge out the interior. This opening should not be made any wider than necessary, as it materially reduces the flow of sap by severing additional sap-conducting tubes (p. 3), but it can be made sufficiently long to reach all the decayed heartwood with little or no additional injury to the conducting tubes. The opening should be pointed at both ends. If much living sapwood is cut away at the sides of an opening during the growing season the foliage of the tree should be reduced proportionally by pruning or by stripping the leaves sufficiently to prevent wilting.

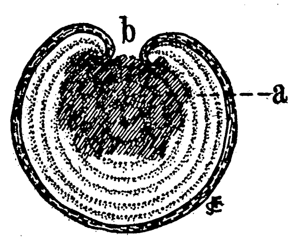

FIGURE 11.—Section of a tree with an old wound partially healed over, showing (*a*) a large decayed area with (*b*) only a small opening visible from the exterior. In excavating the decayed area the cavity should be extended back in all directions into sound wood.

The most important part of this work is to remove the diseased, decayed, or insect-eaten wood, or otherwise check the growth of the fungus organism. Excavating should be continued until sound and uninfected wood is reached. All discolored or water-soaked wood should be removed, unless such excavating is liable to seriously weaken the tree, as this is the region in which the rot-producing fungi are usually most active. Infected wood usually extends some distance beyond the visibly discolored portion. In decayed areas of many years' standing there may be only a thin shell of healthy wood around the cavity, in which case there is danger of the tree being broken by storms unless braced, guyed, or crown-pruned. Unless there is some very special reason for attempting to prolong the life of such a tree it is better to have it removed and replaced by a healthy one.

SHAPING THE CAVITY

All parts of the cavity should be shaped so that it will be impossible for water to remain in any hollow. When the cavity extends below the surface of the ground (rarely at other times), it is not possible to drain it in this manner. Under such conditions the lower part of the cavity should be filled to a few inches above the level of the ground, and the top of the filling sloped so as to throw the water out of the cavity in case the whole cavity is not to be filled. Asphalt and sawdust (or asphalt and sand) are excellent mixtures to use in such places (p. 31).

It is doubtful practice to have a deep water pocket at the bottom of a cavity with drainage provided through an auger hole bored from the exterior. An open untreated hole of this sort commonly becomes

a favorable lodging place for insects, fungous spores, yeasts, and bacteria, resulting in slime flux. Such organisms usually readily infect the wood back of the filling by growing through the hole.

As already emphasized, great care must be exercised in working around the cambium, and all cutting tools must be kept very sharp. The final cutting along the edge of the bark and sapwood can often best be made with a very sharp knife or drawshave. This cutting must be followed immediately by a coating of shellac, which should cover the cambium and a narrow strip of the bark and the adjoining sapwood (p. 19).

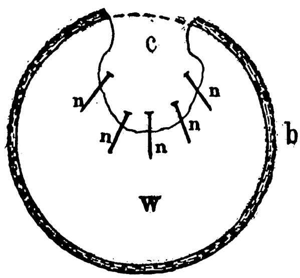

FIGURE 12.—Section of a tree cavity, showing how it is undercut at the margins to assist in holding a plastic filling in place; it also shows nails driven into the back of the cavity for a similar purpose; *b*, Bark; *c*, cavity; *n*, nails; *W*, wood.

UNDERCUTTING

In cutting out decayed wood where the cavity is to be filled with some plastic substance the sides often may be undercut (fig. 12), so as to hold the finished filling more firmly in place. However, when this is done care must be taken that the wood at the edge of the opening is not very thin, as this promotes the drying out of the sapwood and bark at these points. Ordinarily the edges should be at least three fourths of an inch thick (1½ inches is better). When possible it should include the full thickness of the sapwood. Usually the inrolled bark and wood at the sides of an opening will have to be cut away, in order to remove the decayed and infected wood. As a substitute for the undercutting (when a substitute seems advisable) one or more strips of wood can be nailed around the cavity, the outer surfaces of which are level with the cambium (fig. 13), or slightly below it. These strips should be painted with tar or asphalt so as to waterproof them.

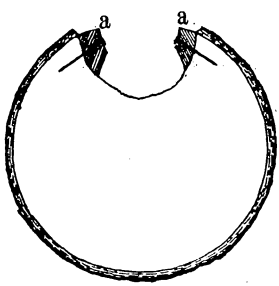

FIGURE 13.—Section of a tree cavity, showing how strips of wood (*a*) can be nailed along the edges to prevent the inrolling of the new callus growth and at the same time to hold a plastic filling more firmly in place. In open cavities the back edge of the strip should be beveled, as indicated, so as to allow ready inspection of all parts of the cavity; in cavities to be filled, the back edge should not be beveled.

STERILIZING

After the decayed and diseased matter has been excavated and the edges of the sapwood and bark adjoining the cambium shellacked, the remainder of the cavity also must be sterilized. As already stated (p. 21) creosote appears to be one of the most efficient preparations to use. Every exposed part of the wood and bark must be sterilized, and over this and the shellacked portion a heavy coating of tar, hot asphalt, or some other suitable dressing applied.

This completes the essential operations in cavity work. Filling a cavity is of much less importance and in many cases entirely unnecessary.

OPEN CAVITIES

A cavity that has been properly cleaned, sterilized, and dressed in the manner already described is in condition to be left, with annual or more frequent inspection, in comparative safety for years. The new

growth of wood and bark along the margins will gradually form an inwardly rolled edge if there is no filling or artificial ledge (fig. 13) to force it across the cavity. This growth may not be objectionable if the crevice back of it can be kept clean and free from insects. Such a growth of inrolled wood commonly stiffens the trunk more than the average filling, for it acts much the same as an H- or T-beam in structural work, and it has the normal flexibility of the wooden trunk. Practically all shallow cavities should be left open, for with few exceptions there is no safer, simpler, or more satisfactory method of handling them.

An open cavity may be regarded as a hollow wound. All the precautions regarding inspection and repair mentioned in the italicized paragraph on page 23 and in the paragraph following it apply with even more force here than they do in the case of flat wounds.

BOLTING

Crotches in trees are often split during a heavy windstorm, or by the weight of snow or ice. Sometimes the wood above or below a cavity will split, perhaps from a sudden cold snap (frost crack) or from other causes. In such cases, where it is possible, bolts should be used to pull the parts together and close the crack. Under most conditions, particularly in large trees, it will be necessary to pull the limbs together so as to close the crack properly before boring the hole for the bolt. This may be accomplished by using a rope and tackle blocks some distance above the crotch. When tackle blocks are used care must be taken to have an abundance of bagging or other padding between the bark and the encircling ropes, or, better, a short piece of heavy belting a few feet in length, with a heavy metal loop at each end for attaching to the tackle blocks, can be used. Another method, particularly when tackle blocks are not available, is to loop a stout rope around the two well-padded limbs and tie the ends firmly together. A heavy or stiff bar is then placed between the two parallel portions of the rope about midway between the two limbs and used to twist the rope, thus drawing the limbs together sufficiently to completely close the crack, after which the holes are bored and the nuts screwed up tightly before the rope is untwisted and removed.

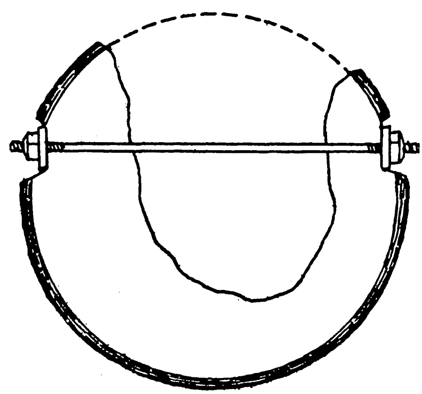

FIGURE 14.—Section of a large tree cavity, showing how a single bolt should be placed to hold the sides rigid.

Often a single bolt can be used for this purpose (fig. 14). In certain cavities or crotches it may be necessary to place bolts at different angles (fig. 15). In either case a strip of uninjured bark and cambium at least an inch wide should be left between the edge of the cavity and the end of the bolt, if it is possible to do so. On medium-sized trunks, after deciding where bolts can most efficiently be placed, a sharp bit (or auger) a half inch or more in diameter and sufficiently long to reach through the trunk and cavity can be used to bore the hole for the bolt. On large trunks a larger bit should be used, and it may be necessary to

bolt, weld, or otherwise fasten on an extension to the shank of the bit. This can be done by any good blacksmith, machinist, or garage worker.

Iron or steel washers (preferably oval) about three times the diameter of the bolt (fig. 16) may be countersunk into the wood by carefully cutting away the bark and wood at both ends of the hole with a sharp gouge or chisel. The washers should be ample and heavy, but not so broad as to make it necessary to cut away an excessively large piece of bark. In most trees when round washers are used it is advisable to have the bark adjoining this countersunk area somewhat pointed above and below the washer (fig. 17). By holding the two washers in place, the length of the iron or steel machine bolt can be measured through the hole. The bolt must be thick enough to fit snugly in the hole and should project beyond each washer at least one fourth of an inch. The thread at each end of the bolt must be coarse and sufficiently long to permit drawing in the sides of the cavity as the nuts are screwed up firmly against the washer. A chamfered single-headed bolt may be used if preferred. Before the bolts are finally put in place the countersunk cuts and bolt holes should be tarred or creosoted,and after the bolts are in place all exposed parts of wood, bolts, and nuts should be waterproofed. If the washers and nuts are sunk deeply into the wood the holes at the ends of the bolts may be filled with cement or asphalt to the level of, or slightly below, the cambium. This will make a neater looking job and leave the spot in better condition for healing over with a smooth surface, but a socket wrench will have to be used to tighten the nut. In some cases a threaded bolt without nuts will be sufficient.

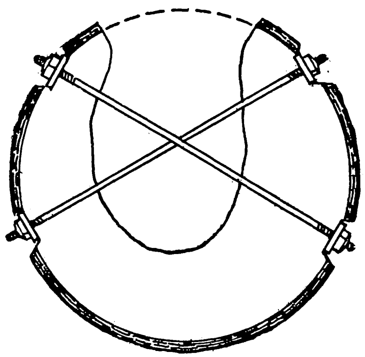

FIGURE 15.—Section of a large tree cavity, showing how two bolts should be placed to hold the sides rigid.

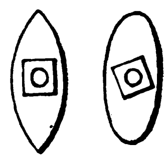

FIGURE 16.—The ends of two bolts with oval washers. The long diameter of the washers should run lengthwise of the trunk or limb.

All split cavities must be securely bolted, particularly near the upper part, after the limbs are drawn together as already described. If the split is an old one and comes from a crotch, all decayed and diseased wood should be removed from the split and an antiseptic wash and dressing applied, after which it can be bolted just beneath the crotch (fig. 18, *a*), so as to hold the parts in their original position. If the limbs are large and heavy a second bolt (fig. 18, *b*) may be necessary above the crotch. It usually is advisable to fill (as described on p. 30) any cavity left in a crotch after it has been properly treated and bolted, and often also to guy the limbs above the crotch. If the split is a recent one, an antiseptic wash alone usually will be sufficient before bolting the sides together. Except on heavy work or when a crack is to be closed by means of bolts and nuts, washers

often are unnecessary. Some commercial workers use a coarsely threaded bolt which is screwed tightly into the hole and no nuts are used. Finally, all exposed edges of the crack must be covered with a waterproof dressing. If necessary, limbs above split crotches may be guyed above the bolts (p. 15).

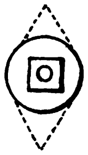

FIGURE 17.—The end of a bolt with a round washer. Triangular pieces of bark should be cut away above and below the washer, as indicated by the broken lines.

COVERED CAVITIES

Sheet tin, zinc, copper, iron, and other metals, as well as canvas and various other materials, have been used to cover cavities. When properly applied, these coverings often assist in keeping out disease, decay, and insects for a long time and usually assist in forcing the new growth across the opening. If the covering has been done improperly or if the cavity itself has not been properly treated, a covered cavity is a much greater menace to a tree than an open one.

In preparing a cavity for a covering, all the decayed, diseased, and insect-eaten wood should be removed in the manner already explained, with two modifications: (1) It is not necessary to undercut the edges of the cavity, and (2) there should be a narrow half-inch ledge of wood around the margin of the cavity from which the bark has been removed and to which the edge of the covering can be tacked (fig. 19). The cavity must be thoroughly sterilized and dressed, in the way already described. Sheet metal or other coverings should be trimmed so as to fit the opening, but should leave a strip of bare wood one sixteenth to one eighth of an inch wide between the edge of the metal and the edge of the bark. This often can best be done by making a heavy-paper pattern to fit the opening, allowing it to curve outward to conform to the general shape of the trunk or to curve inward so as to allow for contraction or expansion of wood during sudden changes of temperature. The metal can then be cut the same shape as the paper pattern. By placing the metal on a block of wood, holes a half inch or an inch apart can be punched or drilled along the margin, through which slender flat-headed brads or nails may be driven into the ledge of wood around the cavity, or if the metal is not too hard the nails may be driven directly through the metal. The inner side of the metal should be freshly painted, preferably with asphalt or tar, the entire cavity already having been properly treated. The metal should be put in place and nailed with a light hammer. Two or more pieces of sheet metal with overlapping joints should never be used unless these joints are soldered airtight. If all insect tunnels have not been cut out, the cavity should be fumigated by saturating a wad of cotton or cotton waste with carbon disulphide and suspending it with a string in the top of the cavity for 12 hours or more before the metal is permanently nailed to the wood at the top. Carbon disulphide should not be used near a fire or an open light, as under such

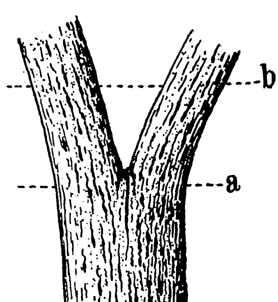

FIGURE 18.—A split crotch; the dotted lines *a* and *b* indicate the position in which bolts should be placed to hold the split.

circumstances it is very inflammable.[4] Carbon tetrachloride is sometimes used instead of the disulphide. This is noninflammable but less effective, and more of it has to be used. One or two teaspoonsful of the carbon disulphide usually will be sufficient for each cubic foot of cavity. During the fumigating process the cavity must be tightly closed and sealed with putty, clay, or some equally effective substance.

The final operation is to waterproof the outer surface of the covering, the edges of the bark, and the strip of wood between them, taking special care that the tacked edges of the metal are made as airtight and insect-proof as possible. During all parts of the operation every possible precaution should be taken to prevent the cambium from being bruised or unnecessarily cut. Such covered cavities should be closely watched for defects, particularly about the edges of the cover, and any defects detected should be immediately repaired.

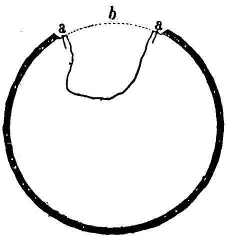

FIGURE 19.—Section of a tree cavity, showing the marginal ledge of wood (*a*) to which a sheet of metal (*b*) can be tacked to cover the cavity.

FILLED CAVITIES

Cavities made by cutting out decayed wood may be filled in various ways with various materials, if for any reason it seems best to fill them at all. Three methods of doing this are described in the following pages. The principal object of any filling is to prevent the new growth of wood and bark from rolling or curving into the cavity, and to assist this new growth in reaching across the cavity more quickly. Fillings do not ordinarily materially strengthen the trunk or limb, as many people suppose. In this connection it is well to remember two things: (1) That a very large or wide cavity will rarely if ever completely heal over, certainly not for many years, and (2) that the uncut callus growth that rolls into a hollow trunk from the edges of an unfilled cavity probably strengthens the trunk more than any filling that involves the cutting away of this callus growth.

FILLING CAVITIES WITH CEMENT MIXTURES

The material most commonly used in this country for the past 25 or more years to fill tree cavities has been cement mortar or concrete. This material is not recommended for filling all cavities. However, as it often holds fairly well in small globular cavities, or even larger cavities in the roots or base of the trunk where there is practically no movement when the wind blows, and the material is so readily obtained and easily worked, a brief description of one of the simplest methods of handling it is included here.

A cavity that is to be filled with cement should be prepared as indicated on page 24, particular care being given to undercutting or bolting, or both, in larger cavities. Bolts serve not only to support the walls of the cavity but also to prevent the hardened blocks of cement from falling out when there is little or no undercutting, or when the filling becomes loosened by the bending of the tree. In the latter case the bolt is a disadvantage, for a tree is better off if a loosened filling is not held in place. Another way to hold the cement in place is to drive large nails or staples half their length into the back

[4] See Farmers' Bulletin 799, Carbon Disulfide as an Insecticide.

and sides of the cavity, so that the projecting heads are finally embedded in the hardened cement (fig. 12).

A good grade of portland cement and clean sharp sand free from loam should be used. One part of the dry cement and 2 or 3 parts of the sand should be thoroughly mixed before adding sufficient water to allow its being worked into a stiff mortar. This mixture is put into the cavity with any suitable trowel and lightly tamped into a close contact with the dressed walls of the cavity. After partially setting, the surface can be worked over with the trowel until moist and smooth. The surface of the finished filling should be no higher than the cambium, as indicated by the dotted lines in figures 12, 14, and 15. Preferably it should be finished about an eighth of an inch below the level of the cambium and the exposed wood at the edges kept thoroughly waterproofed until the new callus has grown down into close contact with the cement. If the cement mixture is too thin it may be necessary to hold it in place until partially set. A simple way of doing this is to wrap a piece of heavy cloth around the lower part of the cavity, keeping it loose enough to allow it to curve outward to about the contour of the trunk when the cement is tamped into place back of it. Before the cement has fully hardened, this cloth dam should be removed, and the cement finished back to just below the cambium line.

FILLING CAVITIES WITH ASPHALT MIXTURES

For covering large wounds as well as for dressing cavities, asphalt apparently is not excelled by any other substance mentioned in this bulletin. The asphalt (also called asphaltum) is the residue of the distillation of some of the western petroleums, and varies in melting point from the boiling point of water upwards. It is a black, essentially solid substance, which when cold can be slightly impressed with the end of the thumb nail. The firmer and harder grades (sometimes know as "mastic") are usually preferred, provided they are not hard enough to crack when struck a sharp blow with a hammer. The greatest objection to its use is the fact that it has to be kept melted and used while hot, unless mixed with some solvent. This makes the process cumbersome and inconvenient, which in itself is a serious objection from many points of view, although a coating of clear asphalt, properly applied at the outset, will often last for years without renewal.

As an ingredient of a cavity filler asphalt has few, if any, of the objections mentioned above for cement, because its elasticity and resilience prevent cracking, and it is absolutely waterproof. It is very adhesive and does not readily separate from the wood when properly applied. For filling a cavity it should rarely be used clear, but in combination with coarse, dry hardwood sawdust, excelsior, shavings, sand, asbestos, crushed shells, or some other suitable substance.

An outline of two methods of using a mixture of asphalt and sawdust to fill a cavity will serve in general for the other mixtures mentioned. The first method will be more useful when a fire or stove can be used near the tree, and the second where this is impracticable, as, for example, on a well-kept lawn or near shrubbery that might be scorched by the heat. However, neither method is recommended in preference to the wood filling described in the next section, owing primarily to the difficulty of getting a mixture stiff enough not to slump when exposed to hot summer sunlight.

First method.—Thoroughly melt the asphalt in a kettle or other suitable receptacle and slowly stir in coarse, dry hardwood sawdust. Continue adding the sawdust as long as the particles can be partially blackened by the asphalt after several minutes' stirring. This hot pasty granular mixture can then be placed in the cavity, which has been prepared as already described, and pressed or tamped into close contact with the side of the cavity before it hardens or cools. For placing the mixture in the cavity, which already has been dressed with clear, hot asphalt, a trowel, paddle, or ladle can be used. The tamping stick should have a smooth and slightly rounded end. The end may be covered with sheet metal if desired, or a tamping rod made of iron may be used. If the mixture adheres to the end of the tamping stick to an extent that interferes with the work, a quick twist as it is about to be withdrawn will usually improve conditions. It may be necessary to grease or wet the end of the stick frequently. Often the best results are obtained when a steady, slow, heavy pressure is exerted rather than a quick tamping movement. A very excellent 2-foot tamping stick can be made from a shovel handle. The grip at the end gives a ready purchase for the twisting motion. The opposite end of the stick should be rounded, sandpapered, and soaked in a lubricating oil or in hot tallow for some hours before being used.

Second method.—Mix the asphalt and sawdust in a kettle, as described above, over any suitable stove or fire anywhere that may be most convenient. When thoroughly mixed, dip it out of the kettle and place it on sheet metal to cool in the form of pancake-shaped or biscuit-shaped lumps, whichever form may be the most conveniently used or handled. The sheet metal may be greased or not. The asphalt mixture can be removed when cold by tapping the metal or, if necessary, by applying a blast torch to the back of the sheet metal. Another and often more convenient way of preparing the lumps is to drop the hot mixture into shallow molds made in the ground or in sand, and brush off the dirt or sand when the lumps are cold. These lumps can then be transported wherever they are to be used, or they can be stored indefinitely for future use. When used for filling a cavity, they may be kept whole or broken into pieces. A blast torch may be used to soften the surface of the lump sufficiently to allow it to pack more readily into a cavity before it is pressed into place and nailed firmly to the wood, or the lump may have nails driven into it and then be partially or completely dipped in melted asphalt and immediately nailed into the cavity. All the lumps should be nailed firmly in place. Small sheets of wire netting, metal lathing, burlap, or canvas often can be nailed or stapled over different layers of the asphalt mixtures with good results; preferably so they will not show on the surface when finished. This operation, perhaps with slight modifications, is repeated until the whole cavity is filled. When the blast torch is used in the interior of the cavity care should be taken that the cambium is not overheated. A simple way of preventing overheating is to have a broad paddle of wood, fiber, or other nonconductor of heat that can be held over the cambium and bark with one hand while the torch is being used with the other. After a little practice, the torch will rarely have to be used inside the cavity.

After all the decayed matter has been removed and the cavity sterilized and properly dressed, there is no immediate danger in delaying subsequent operations if for any reason such delay seems necessary or desirable. Moreover, it is unnecessary to put all the filling compound into the cavity the same day, or the same week, or even the same month. After asphalt mixtures have cooled, the hot sticky surface can be restored by passing a hot iron over it or by protecting the cambium and using a blast torch. This heating of the surface should be done just before another batch of filling is added, especially when the first method mentioned is used.

When a cavity has been filled by either method, the surface of the filling can be finished off with a hot iron to an eighth of an inch below the level of the cambium. In no case should it be allowed to project beyond the dotted lines shown in figures 12, 14, and 15. Frequent failures of this type of filling are usually due either to an improper mixture of asphalt and sawdust or to inefficient methods of holding the filling in place. If a sufficient quantity of sawdust has not been mixed with the asphalt or if too much clear asphalt has been used to

cement the lumps together when the second method is used, the composition will slowly slump, pull away from the wood at the top, and flow out at the bottom of the cavity. To prevent this slumping, the surface of the finished filling may be covered with canvas, closely woven burlap, thin strips of wood, wire netting, metal lath, or other suitable covering, and held in place with long nails, screw bolts, or staples that reach into the solid wood at the back of the filling. If the bolts, nails, or other staples are too thick to be driven through the asphalt without cracking it, they can be heated and slowly pushed through to the wood. In shallow fillings a simple way is to drive in closely set long nails, each nail passing through a large washer. As a rule, if these washers are closely set no other covering is necessary. When any of these surface coverings are used, the outer face should be no higher than the level of the cambium and should finally be dressed with tar, asphalt, or paint.

Care should be taken to avoid bruising or unnecessarily heating the cambium at any time. A very good tool with which to finish the raw surface near the cambium is a small mason's trowel, the tip of which can be heated for a few seconds at a time in the flame of a blast torch. A tool of this general shape with a thin edge but with more metal at the center is better and will hold the heat longer. For finishing farther away from the cambium a larger and heavier tool will be more useful, e.g., an old-fashioned flatiron. If masses of asphalt project too far beyond the contemplated finished surface to be smoothed readily with a hot trowel, they can be cut off with a hot trowel, or with a cold chisel and hammer, before the surface receives its final smoothing.

Thinner mixtures of asphalt and sawdust than indicated above (or even clear asphalt) may be used when the cavity is so situated or shaped that the mixture cannot run out if softened by a high temperature. This applies particularly to cavities on the upper side of a nearly horizontal limb and to those extending downward from an opening in the trunk or in a crotch. However, in most deep cavities a better method is to fill roughly with wood (see next section) to about an inch or less back of the cambium and finish with an asphalt mixture, as just described.

FILLING CAVITIES WITH WOOD

Asphalt or asphalt mixtures can be used along with blocks or strips of dry wood (such as laths or scantlings) for filling cavities. When blocks or strips of wood are used as the main filling substance they can be trimmed roughly to fit into various parts of the cavity or into the whole cavity and painted with asphalt or tar so as to waterproof them before they are nailed in place. An entirely satisfactory way to do this is to cut a strip of the desired length with a handsaw and then use only a small, sharp hand ax and small chopping block to trim it roughly to fit the desired place, then remove it from the cavity, and drive the required nails or staples part way through it.

The back of the block or strip and that portion of the cavity in which it is to be placed should be covered with a thick coat of hot asphalt, and the strip nailed in place. If the wood strips used are soft or easily split, it will be safer to use coal tar, as cold asphalt will sometimes cause the wood to split before the asphalt will yield. If the wood should split, the crack should be filled with coal tar. A

long heavy nail set, a center punch, or a saddle punch may be useful in driving the nails or staples into the strips. At times it may be advisable to use screws or bolts instead of nails or staples. The blocks or strips of wood need not be very carefully fitted, because the asphalt mixtures, particularly asphalt and sawdust, will fill practically all spaces between them. It usually does no harm if some spaces are not filled, provided they are not at the surface of the filling. The grain of the blocks or strips may run lengthwise of the trunk and extend the entire length of the cavity, at least when near the surface, or it may run across the cavity, or in different directions in alternating layers. Each method seems to hold equally well.

In large cavities, when the grain of the strips runs lengthwise of the trunk, a strip or layer of strips an inch or two thick may first be placed in the back of the cavity and then the building up done mainly from the sides (fig. 20). If such a filling is planned so that there will be an unnailed but thoroughly asphalted closely fitting joint extending the length of the cavity and from the layer of strips first nailed to the back of the cavity to its outer surface (fig. 20, *a–c*), there will be very little danger of the filler pulling away from the sides of the cavity as a result of a contraction of the sapwood during a cold spell. In such a filling the opening, if it comes, will be along the line of least resistance, which in this case will be, almost invariably, the unnailed joint lengthwise of the filling. In section this joint may be a straight or a zigzag line, preferably the latter. As the crack closes when the weather becomes warmer the asphalt will usually cement the two edges of the joint together again; but even if it does not, both surfaces of the crack still will be covered with waterproof asphalt.[5] If the strips of wood used in the cavity are creosoted before they are put in place, the danger of infection as a result of wetting is still further safeguarded. The exposed surface of the completed filling should be trimmed back to about one eighth of an inch below the level of the cambium, either before or after the strips are nailed in place, so as to conform more or less closely to the shape of the trunk (fig. 20), and finally painted with hot asphalt, coal tar, or paint of any desired color.

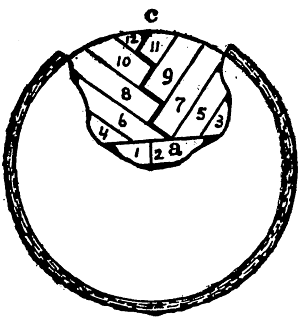

FIGURE 20.—Section of a tree cavity filled with strips of wood. The numbers on the strips indicate the order in which they are inserted. No nails are driven across the zigzag line *a–c*.

For keeping the asphalt melted, some sort of heater will be required. In most cases one that is readily portable will be most useful, for the asphalt can usually first be melted over some less portable heater or stove and the portable heater used merely to keep the asphalt melted while it is being used. Often it will be most convenient to have a rather small heater, such as some blast torch, or a plumber's or tinsmith's stove—possibly one that can be suspended by a padded wire from a limb of the tree. A galvanized-iron pail with a capacity of about 10 quarts or less may be useful for this purpose. The bail socket should be riveted to the pail. With a little ingenuity one of

[5] Excellent preparations to use between the strips of wood, containing asphalt and asbestos, can readily be purchased of dealers in roofing materials or flashings, and they have the advantage of being mixed ready for use without heating. At times it may be an advantage to mix sawdust or some similar substance with them.

the heaters mentioned above can be altered so that it may be suspended by means of two long hooks to the bail sockets of the pail or to the top of the pail, and the pail and the attached heater carried about by the bail, yet the two can readily be separated if desired. The pail and heater can be suspended from the limb of a tree by a padded hook, or the heater can stand on a board on the ground and the pail be set on top of it.[6]

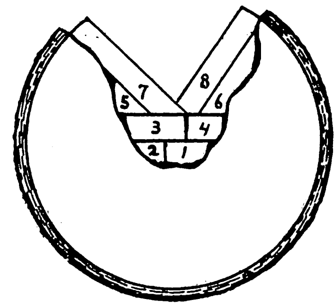

FIGURE 21.—Section of a tree cavity partially filled with strips of wood. The numbers indicate the order in which the strips are inserted.

Oftentimes it is neither necessary nor desirable to fill a cavity completely; or perhaps the necessary time to complete the work promptly is not available. Under such conditions the cavity can be cleaned out, sterilized, and dressed. If an inrolling callus is objectionable, strips of sterilized or waterproofed flexible wood can be nailed along the edges of the cavity, the outer edge of the strip being no higher than the cambium line (fig. 13). In most cases if this strip is a half inch thick it will for some time prevent the new callus growth from rolling into the cavity, and before the new growth has reached across it another strip can be nailed over it, or the cavity completely filled. If these strips are used it will be necessary to fill the small pocket back of the strips at the bottom of the cavity with wood or some plastic substance, so that it will not hold water.

If it is impracticable or inconvenient to use hot asphalt and sawdust or some of the commercial materials between or behind the strips of wood in filling a cavity, a substitute can be found by mixing sawdust with creosote and asphalt (p. 21), or with coal tar, or even with paint. Perhaps the best home-made substitute for the heavy asphalt is a mixture of coal tar and dry sawdust. This mixture does not necessarily have to be heated during any part of the operation unless the work is done in very cold or freezing weather. It is better, however, to have the tar hot when the sawdust is being mixed with it. No definite proportions for the tar and sawdust can be recommended, because the quantity of each ingredient is largely dependent upon the grades and kinds of sawdust and tar that are used. In his own work the writer has found that 1 part of thoroughly dry sawdust by weight to 3 or 4 of coal tar or 3 to 4 parts of sawdust by bulk to 1 of coal tar give a mixture of about the right proportions. The mixture should be stirred (preferably when warm) until it is of an even consistency—somewhat granular but sticky and pasty. When put in the dry cavity, it should readily stick but should not be thin enough for the tar to ooze out, at least not until the mixture is compressed by nailing or stapling the wood strips firmly in place over it. It will be advisable

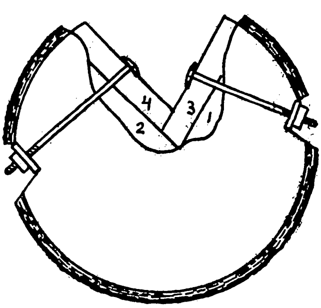

FIGURE 22.—Section of a tree cavity partially filled with strips of wood; these are bolted to the walls of the cavity. The numbers indicate the order in which the strips are inserted.

[6] See footnote 5.

to paint with clear coal tar the exposed wood, the strips that have been fastened in the cavity, and the back of the strip that is to be inserted before inserting the sawdust and tar mixture (p. 35).

Generally, when the strips run lengthwise of the cavity, some such arrangement as is shown in figures 20, 21, and 22 will be found most advantageous, as such an arrangement permits more freedom in driving the nails or staples, or in placing the screws or bolts in position through the strips. The edge of the strips at the surface should be trimmed off in a line no higher than the cambium, as shown in figure 20, or the strips may be trimmed back to a line behind the cambium and 1, 2, or more thin strips of sufficient thickness to bring the surface nearly up to the cambium line nailed, screwed, or bolted over it to form an outside layer, as shown in figure 23. Another method is to replace the strips numbered 11, 12, and 13, in figure 23, with a layer of asphalt and sawdust, as described in the preceding section. The order in which the strips may most conveniently be placed in the cavity is indicated by the order of the numbers on the strips in figures 20, 21, 22, and 23.

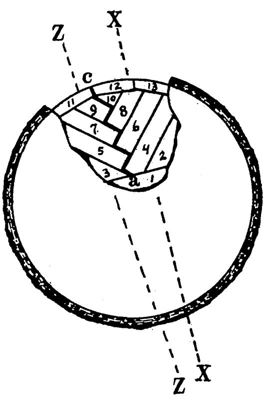

FIGURE 23.—Section of a tree cavity filled with strips of wood, with a thin surface layer of strips (nos. 11, 12, 13). The broken line *X–X* indicates where a bolt, when necessary, should be located to hold the ends of a filling, as indicated in figure 21. Occasionally it may be necessary to place bolts at both *X–X* and *Z–Z*. No bolt should pass through the unnailed zigzag joint *a–c*.

In long fillings, particularly in flexible branches when the grain of the wood strips runs lengthwise of the cavity, a bolt and metal washer near each end of the filling, and perhaps another at the center, will prevent the ends or center working loose. Figures 22, 23, and 24, with their legends, will explain the details of placing the bolts and washers. The bolt and washers will rarely be needed when the grain of the wood runs across the cavity or when alternating layers of strips are at different angles to the adjoining layers. If the smooth surface of any type of filling is esthetically objectionable it may be carved, modeled, or painted to imitate more or less closely the natural bark, but if this is done the surface of the filling should not cover the edge of the cambium at any point.

COMPLETED WORK NEEDS WATCHING

Tree owners and superintendents of trees in parks, on streets, and on other public land often neglect to keep close watch of their trees, in order that defects which appear in the work may be repaired promptly and new injuries elsewhere on the tree may have immediate attention. This statement applies to all pruning wounds and cavities, either filled or unfilled. If a tree is of sufficient value to warrant proper and careful treatment, it certainly is worth the slight expense of subsequent annual inspection and the immediate treatment of newly discovered injuries at a time when the necessary outlay to keep the tree in good condition will be comparatively small (p. 13). Opera or field glasses will be an aid to any such inspection made from the ground.

PERSISTENCE OF SCARS

It should be borne in mind that scars where large limbs have been removed, or large cavities filled or left open, will be unsightly spots to the majority of people for years, even under the best of conditions. If the scar is a large one, it may never entirely heal over before the tree succumbs to other destructive agencies, and consequently it may remain a permanently conspicuous defect (p. 4). It might so happen that a large scar or filling would be too unsightly and conspicuous to please the owner. Here, again, greater satisfaction may be realized in the end by having the diseased tree replaced by a healthy one.

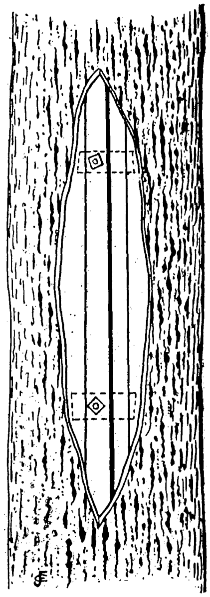

FIGURE 24.—Surface view of a tree cavity filled with strips of wood, as shown in section in figure 20; the surface has not yet been waterproofed. The broken lines show the position of the bolts and the broad washers. The washers should be of heavy iron and wide enough to reach across all the strips at the point where they are placed. The bolts should not pass through the unnailed joint *a–c* indicated in figures 20 and 23.

COMMERCIAL WORK

If a tree owner prefers to employ a commercial worker to attend to his trees, it may be advisable to have a definite written contract concerning at least certain important phases of the work, in addition to specifying the price and the methods of payment. Besides the type or types of finished cavity work, the following are suggested as points that may be incorporated in the contract—points to which no reliable tree worker ought to object:

(1) No climbing spurs shall be used on any part of a tree.

(2) The shoes worn by the workmen shall have soft soles.

(3) In cavity work all diseased, rotten, discolored, watersoaked, or insect-eaten wood shall be removed and the cavity inspected by the owner or his agent before it is dressed.

(4) Ordinary commercial shellac (p. 19) or some other efficient covering shall be applied to the cut edges of sapwood, bark, and cambium within 5 minutes after the final trimming cut is made, or as soon afterwards as the surface becomes sufficiently dry.

(5) All cut surfaces shall be painted with shellac or creosote, followed by thick coal tar or asphalt, or other equally permanent covering.

(6) The contractor shall repair free of expense any defects that may appear in the work within 2 years.

Under certain conditions various modifications of these suggestions may be advisable, but alterations in nos. 1, 2, 3, and 6 should be made with caution. If certain crotches are split or particular limbs on some trees need bracing, it may be well to include a statement of just what limbs shall be removed from particularly choice trees. And, last but not least, some provision should always be made for the regular inspection of the trees every year, unless the owner or the superintendent of street and park trees prefers to do this himself.

ADDITIONAL INFORMATION AND SUGGESTIONS

The treatment of tree wounds has not received the support that it warrants from tree owners and officials in charge of public grounds,

including streets and roadsides. This at times may be due to unfavorable experiences with ignorant tree workers, particularly in regard to cavity work; at other times to the reluctance of the owners to spend much money in preserving their trees, or to ignorance of the benefits that may result when the work is properly done. Reliable and conscientious tree workers are doing much in a practical way to show the public that injured trees will favorably respond to proper treatment.

The practice of treating tree wounds is very old and probably all of the best methods are well known. Tree owners should regard with suspicion all persons or firms who claim or intimate that the work is a secret art. They should be particularly cautious about allowing persons to work on their trees who claim to have secret methods of curing or treating disease, decay, or insect injuries in trees. Cases still are occasionally reported where tree owners have been victimized by fakirs who bore holes into tree trunks and insert some reputed secret "cure-all" preparations.

A few States, notably Connecticut and Rhode Island, have laws regulating work on a commercial basis. This is a decided step toward improvement and standardization of methods and better cooperation among workers.

The Department of Agriculture invites correspondence concerning methods in treating trees that have been injured. By cooperation of this sort the practice of tree treatment ought ultimately to attain a higher place in the estimation of the general public than it now holds.

Finally, tree owners are urged to remember at all times that the necessity for extensive work on a tree 15 or 20 years hence may be reduced very materially by promptly attending to the fresh injuries of today.

It is believed that the methods described in this bulletin are not covered by letters patent granted to any individual, firm, or corporation, but the Department of Agriculture assumes no responsibility in this connection.

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